H. A. MacGregor

PATHWAYS · IN · SCIENCE · IV
SCIENCE FOR ELEMENTARY SCHOOLS

THE TEACHERS' MANUAL

TO ACCOMPANY

"The Earth and Living Things"

By GERALD S. CRAIG
Assistant Professor of Natural Sciences
Teachers College, Columbia University

and BEATRICE DAVIS HURLEY
Teacher in Horace Mann School,
Teachers College, Columbia University

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Teachers' Manual

INTRODUCTION

The purpose of this manual is to give guidance to those teachers who use the text, "The Earth and Living Things," in their classes. The manual is intended to be merely suggestive of what may be done. The teacher is free to make her own plans for teaching any part or the entire textbook.

"The Earth and Living Things" is designed primarily for the fourth grade, but special conditions may make its use desirable at other levels — for instance, in the high third or low fifth. "The Earth and Living Things" is one of the series entitled Pathways in Science, a course for the grades of the elementary school.

Curricular Studies Basic to the Series

Pathways in Science is based on a number of studies of science in the elementary school made by the authors of these texts with the assistance of hundreds of teachers in the elementary schools. These studies [1] are as follows:

1. A study of *present practices* in science in the elementary schools. Hundreds of handbooks, source books, syllabi for teachers, courses of study, and professional articles were examined to determine the nature and scope of the objectives and content in elementary science and nature study. Supervisors, administrators, and teachers of science from various parts of the country were interviewed. In fact, every available means of inquiring into present practices in the teaching of elementary science and nature study was used.

2. Construction of a *list of objectives* of elementary science based upon the study of (*a*) articles in the volumes of *Nature Study Review* and various elementary-school journals, (*b*) courses of study in elementary science and nature study, (*c*) professional literature, (*d*) authoritative treatises in astronomy, biology, chemistry, geology, and physics.

[1] Gerald S. Craig, Certain Techniques used in Developing a Course of Study in Science for the Horace Mann Elementary School, Teachers College. Contribution to Education No. 276, Bureau of Publications, Teachers College, Columbia University, New York, 1927.

3. Evaluation of the objectives described in 2 on a basis of *educated laymen's judgment of needs.*

4. Evaluation of the objectives on a basis of their *need in answering children's questions.* About 7000 questions from children in both rural and city schools were utilized in this study.

5. Evaluation of objectives on a basis of *meanings developed* in authoritative source books of science.

6. Analysis of objectives to determine their *constituency,* and evaluation of objectives on a basis of their meanings to the child.

7. Analysis of *related elementary-school subjects,* such as geography, health, household arts, in order to determine their specific need of science in the elementary grades (unpublished).

8. A study of *grade placement* by an experimental try-out in the Horace Mann Elementary School, Teachers College, New York City (unpublished).

The Horace Mann Course of Study in Elementary Science [1] was constructed on the basis of the preceding studies. This course of study has been tried out in thousands of classrooms in all types of schools, from the one-room rural school to the large city school system, in various parts of the United States as well as in other countries. This has given opportunity for the widespread reaction and criticism which has been compiled and utilized in organizing the content for Pathways in Science.

Mr. Robertson,[2] at the University of Michigan, in a recent study of six units taken from the fifth grade of Horace Mann Course of Study, finds that "the subject-matter materials used in this investigation were entirely practical for use with pupils" of fifth grade in the school in which he performed the experiment.

This series of books definitely conforms to the recommendations and spirit of the Thirty-first Yearbook, Part I, of the National Society for the Study of Education, and is designed for those school systems which desire to introduce a continuous program of science throughout the elementary school. The books, however, are graded in such a way that they may be introduced separately.

[1] Gerald S. Craig, The Horace Mann Course of Study in Elementary Science (Grades I–VI). Bureau of Publications, Teachers College, Columbia University, New York, 1927.

[2] Martin L. Robertson, A Study of the Relative Effectiveness of Two Methods of Teaching Elementary Science (unpublished study, University of Michigan). A report of this study appears in "Second Digests of Investigations in the Teaching of Science," by Francis D. Curtis, P. Blakiston's Son & Co., Philadelphia, 1931.

Vocabulary checked against Word List

The vocabulary of "The Earth and Living Things" has been checked carefully against the Buckingham-Dolch Word List. The children of the fourth grade will have no difficulty in reading this text. The only over-grade words appearing in the text are the few words that are considered necessary to an understanding of the meanings of science which are to be established. Special care has been taken to develop the scientific concept of the words so that the child may use them intelligently. Provision has been made to see that all the important scientific terms developed in the text are used frequently. In this way the series of books assists the child in developing an elementary vocabulary of scientific words, so essential in modern life.

Elementary Teachers can teach Science

Many teachers of the elementary school have had little or no preparation for teaching science. This series of books has been designed to make it an easy task for any teacher to teach science. The units in the text contain sufficient information in the child's own language to save the teachers from any embarrassment because of their own lack of knowledge.

Throughout the United States there are teachers with little or no background who have been successful in teaching science by using the experimental course of study which preceded the publication of this series. In fact, the elementary teacher, because of her intimate contact with the children, has an opportunity for teaching science which in many respects is superior to that of the departmental specialists in science who come in contact with the children only at scheduled periods. By using the textbook the teacher will find that instruction in science is no more difficult than that of any other elementary-school subject.

"One reason why elementary teachers feel their own dearth of scientific knowledge lies in the difficult questions often asked by children. Children's questions cover a wide field, and many of their questions have never been answered by the scientists. Hence the elementary teacher need not feel chagrined when the children ask questions she cannot answer, but she has reasons for feeling that

her instruction has not achieved its goal if she continually fails to utilize their questions to motivate their work,"[1] or if she discourages the children from expressing their interests. Children's questions can be used to motivate work and to introduce units included in this text. This text is designed to help the child in answering his own questions with the teacher's guidance. The manual will assist the teacher with many additional questions which the authors, on a basis of their own teaching experience and the studies of children's questions, previously described, think are likely to arise in the study of the various units.

Many teachers have found that the children ask more questions than can be cared for in the time allotted to science. However, it is quite possible to keep within the allotted time without discouraging the asking of questions. Some teachers assist the children to select those which are more important or which are appropriate to their own level of maturity and to eliminate those that are less essential. It may be necessary occasionally to tell children that a given question cannot be answered at that time but can be cared for in later units and even in some cases in later grades.

Many questions in science have never been answered. Some of the phenomena experienced every day by boys and girls, such as light and gravity, have not been explained to the complete satisfaction of scientists. Children seem to enjoy the fact that much knowledge remains to be discovered, and teachers should have no hesitation in saying that scientists are not sure of the explanation of this or that particular phenomenon, when that is true.

"It is important that teachers in all grades of the elementary school, either by direct explanation or by implication, guard against causing the children to accept animistic explanations of natural phenomena. Many supplementary books used in the elementary school are characterized by such distortions as animals talking, Nature planning, and the plant and animal world conferring. Every effort should be made in the science activities to interpret"[2] natural phenomena in an elementary but truthful fashion. Every effort

[1] "A Program for Teaching Science," Thirty-first Yearbook, Part I (p. 155), of the National Society for the Study of Education. Public School Publishing Company, Bloomington, Illinois, 1932.

[2] Ibid. pp. 152, 153.

should be made to avoid satisfying the child's curiosity with explanations bordering on the mystic. In the past there has been a constant tendency to provide reading material which mixed fact and fiction to such an extent that the child did not know which was truth about nature and which was myth. The studies basic to this series of books indicate that children want the truth about natural phenomena rather than a sugar coating of fairy tales and pseudoscience.

"The Earth and Living Things" aims to give the child an accurate but interesting treatment.

Developing Scientific Attitudes

Too many times teachers in the elementary school give the child the impression that the content they teach is true for all time. One of the great teachings of science is that man's conception of truth changes. Many, if not all, of man's earlier explanations and ideas have been discarded in the light of scientific study. Everyone should be ready to discard any conception taught today in order to accept any satisfactorily proved fact or scientific hypothesis of tomorrow. This series of books has attempted to give the facts, principles, and hypotheses which are most acceptable to the scientific authorities. At a number of points, however, it has shown how the ideas that men have had in the past have changed. The children should realize that many of our concepts will change in the future. The teaching can in this way establish an attitude of open-mindedness, which is most essential in meeting the adjustments of the future.

In developing this series of books the authors have realized that one of the important contributions of science to the individual is the development of scientific attitudes. Those attitudes are probably best developed by being made acceptable to children. The text aims to make these attitudes acceptable by presenting basic principles and information. The objectives which are closely associated with attitudes are the following:

1. Man's conception of truth changes.
2. It is desirable to have confidence in the scientific method.
3. Nature's principles are invariable.
4. There is a cause for every effect.
5. Much knowledge remains to be discovered.

6. Conditions favorable to life are likely to persist on the earth for a long time; no catastrophe for the entire earth is probable for immense periods of time.

7. Man has become an important determining factor in the environment of many forms of life. His continued existence and advancement are dependent upon his wise modification and control of his environment.

Each of these principles is considered at various places in the series in connection with the regular development of the content. The manual will call attention to the places where these principles associated with scientific attitudes receive development in the text.

Science as a Part of the Elementary Curriculum

There has been a widespread philosophy that science and nature study should be placed on an incidental basis. If a child brought a flower to school, there was a lesson on flowers, or if he brought a snake, there was a lesson on snakes. Science depended entirely upon incidents. It became incidental and frequently accidental in the school program.

We are living in an age in which science plays a large part. Science is gaining ground steadily as a recognized subject in the elementary-school curriculum. The teacher using any of these texts will not need to wait for the pupil to bring in an object in order to have instruction in science. The use of the text will in itself create interest in science if it has not already been manifested.

There is, however, a place for the incidental materials. Teachers can utilize the things that are brought in to motivate the work and to give concrete illustration to the content of the text. This manual will guide the teacher in making use of the incidental material.

There may be some question as to whether all of the material in "The Earth and Living Things" is within the range of interest of fourth-grade children. It is recognized that some of the content may not always be within the present and immediate experience of the children. This fact does not detract from the worthwhileness of even such items. It is the teacher's privilege and duty to lead her children into ever widening experiences — to enlarge their environments, and to open up new fields for study.

Teaching Aids

When possible, trips should be planned to illlustrate the topics discussed in class. In many cases, however, field trips are impracticable, and in such cases the teacher must depend entirely upon other sources for additional illustrative material.

Every teacher should familiarize herself with the visual aids available for her school. Sometimes libraries and museums have loan collections which may be secured. A number of state departments of education likewise lend material of this sort.

Some schools are located near museums. When the exhibits to be found in such museums may be visited, the school is unusually fortunate. The absence of such opportunities may, however, be a blessing in disguise. It will afford an incentive to each school gradually to *build up its own science museum.* A considerable amount of enthusiasm may be awakened in the children to participate in establishing an exhibit which they may be made to feel will be of permanent value. The building up of any effective school museum should not be made a casual matter, but the teacher should plan it as a long-time project extending over a number of years and should make it her aim to accomplish one definitely assigned part of the plan each year.

A table may be set aside for use in science. Materials that are brought in by the children can be displayed for a time on this table. Later they may be placed in the museum cabinets and utilized by other teachers from year to year.

Teachers should write to their state departments of education for information concerning sources of science material that are available for elementary schools. Frequently pamphlets of value to teachers may be secured from state museums, state agricultural colleges, and the United States Printing Office. Catalogues of publications can be secured upon request.

Integration with other School Subjects

Educators generally recognize that there have been too many subjects or categories in the elementary school. Various attempts have been made to consolidate or integrate the individual subjects. Projects, activities, or larger units integrating a number of subjects

have been proposed to remedy this condition. An authentic source of content in science on the grade level of the child is needed in those classes teaching by the activity program. The teacher will find the text a means of checking by which she may determine whether the year's program of activities is properly balanced in science. Science should be considered a continuous program extending like a trunk line through the elementary school regardless of whether it is taught by integrated activities or in separate periods of science.

Suggested Procedure

This book is as applicable to the modern progressive school practice as it is to the traditional school. The books of this series were not written with the idea that every fact must be recited and memorized.

The text supplies for every large meaning a sufficient context, so that in the end the significant meanings are established in the child's mind, although a considerable part of the context may soon be forgotten. Units of later books of the series will cause many of these meanings to be needed in new learning. In the manual additional experiments and activities of various kinds that have proved successful in the past are suggested. The teacher need feel no compulsion about using these suggestions. She may desire to develop her own methods.

The text need not be used from cover to cover. Some teachers may desire to use it as a source book. This may be true especially in those schools which pursue an integrated program. The books are so well adapted to children's use, as a result of the checking of the vocabulary and the complete yet simple index, that they will function in an activity program in which science is completely integrated with other subjects.

The outcomes in science of the instruction in an integrated program may be checked by the essential meanings listed in this manual in order to determine whether the full contribution of science is being utilized at that grade level.

Teachers should feel great freedom as they teach in supplementing the text and manual with other activities. Science is especially well adapted to this type of work.

Plan for the Manual

The general plan of the manual is to give the teacher the following information:

Larger Objectives. The content of each unit gives basic instruction for many fundamental conceptions and principles of science which may become more and more significant as one proceeds through life. "Vastness of space" and "adaptations of life to physical environment" are illustrative of these large conceptions, which are so important in modern life. The texts for the primary grades will help the children to become acquainted with and have experience with these fundamental ideas at an early age. In the earlier grades the content of these "big ideas" is in simple language almost devoid of scientific terminology. The texts in the intermediate grades elaborate and continue the development. The teacher should not be alarmed by the scientific statements as they appear in the larger objectives. She should not attempt to teach them as they are stated. They are given to the teacher merely to indicate the direction that the instruction is to take and to make clear the objectives the authors have had in writing the series.

Essential Meanings for Children. The statements of the essential meanings summarize the chief points in the various units. The children should understand the meanings as a result of their study. The authors have not tried to burden the teacher and children with a lot of insignificant material. The essential meanings represent important goals which are keys to many facts or which have a functional use in life. They represent standards of accomplishment for the various grade levels.

A hasty examination of these meanings may indicate to some that emphasis has been placed upon subject-matter goals to the exclusion of scientific appreciations and attitudes. However, the latter are necessarily concomitants of the development of meanings in the information which is presented in the text.

Information for the Teacher. Every teacher knows the satisfaction that comes from having an ample store of information. In the manual the authors aim to give just the kind of information that a teacher needs for science. The teacher who feels that she has no great background in science should utilize the information

that is given. Every effort has been made through the text and the manual to make it possible for the classroom teacher to give instruction in science.

The authors have aimed to give the setting of the various units in the entire program of science of the elementary school by indicating the relationship with the instruction of the other grades. Frequently the elementary teacher does not know enough about how the learning at her grade level is related to that at other grade levels.

Often the information found in the text is so complete that there is little added in the manual. In that case the information is summarized in a series of succinct statements.

Information and Suggested Procedure. The manual aims to give the teacher the information and procedure which will be helpful in guiding the instruction in science in her class.

Answers to Questions. One feature of this series of books is that there are exercises at frequent intervals in the form of *Things to Do* or *Things to Think About.* Any information necessary for these is given in the text and manual. These questions are designed as thought questions, or problems. These exercises are designed to challenge the children and cause them to do thinking which will utilize some of the significant information of the unit. The exercises do not call for small detailed information, but rather the broader significant and challenging meanings.

The teacher should permit the children to give their ideas rather freely in answering these questions, but in the end she should check them by the information of the textbook or other authoritative sources.

General References for Teachers

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PURPOSE

"The Earth and Living Things" constitutes the fourth book in the series Pathways in Science. Its purpose is the teaching of science in the fourth grade of the elementary school This book is essentially a textbook in science — not a supplementary reader.

The authors are not concerned primarily in making scientists or naturalists of boys and girls, but rather in giving them definite scientific information and attitudes that will help them to understand and interpret factors in their environment which might otherwise remain a mystery.

The scientific conceptions and generalizations which are developed in Book IV are listed in the following section of this manual. Every teacher should become thoroughly familiar with these conceptions, so that proper emphasis may be given to the material in the text. These conceptions are in no way to be memorized by the children. They are given here solely for the teacher's use.

Each book of the series Pathways in Science builds upon what has gone before. Each book prepares children for what is to follow. It seems expedient here to list the themes in Book III which lead directly to Book IV. They are:

I. THE STORY OF THE SKY

A. The Sun, the Stars, and the Moon
B. What the Sun Gives Us

II. PLANTS AND ANIMALS OF LONG AGO

III. ANIMALS OF TODAY

A. What Happens to Animals when the Seasons Change
B. Hunger among the Animals
C. Animal Enemies

IV. HOW ANIMALS CARE FOR THEIR CHILDREN

V. THE STORY OF PLANTS

VI. THE EARTH WE LIVE ON

VII. WATERS OF THE EARTH

VIII. THE AIR AROUND US

IX. MAGNETS AND WHAT THEY DO

Book IV contains nine large units. These units are subdivided into problems for purposes of study. Every teacher using this book should become familiar with the general scheme of it in order to plan a well-rounded year's program of work in science. Each unit is complete in itself, to allow for flexibility of arrangement and thus meet the individual needs of teachers in the field. These units are:

I. THE EARTH

The Earth and Weight
What the Earth is Like
Solids, Liquids, and Gases

II. THE CHANGING EARTH

How the Earth Moves
How Old is the Earth?
Forces which Have Changed the Earth

III. THE AIR AND HOW IT WORKS

The Air We Breathe
How Air Becomes Wind

IV. SOCIAL LIFE AMONG ANIMALS: MAN, BEES

How People Live and Work Together
Life of Honeybees
Life of Some Other Bees

V. SOCIAL LIFE AMONG ANIMALS: ANTS, WASPS, SPIDERS

Life Inside an Ant Hill
Life of Wasps
Life of Spiders

VI. HOW OTHER ANIMALS LIVE

Life of the Beaver
Animals that Live Together at Times

VII. THE VALUE OF ANIMALS AND PLANTS

What Animals Do for Us
What Plants Do for Us

VIII. PLANTS

How to Make a Garden
Plants Without Seeds

IX. TWO FORCES WHICH MAN HAS PUT TO WORK

How Electricity Works
Why Steam Has Power

The units in Book IV lay a foundation for what is to follow in Book V. The following themes developed in Book V are enlargements of conceptions already started:

I. GETTING READY FOR WINTER

Why Plants and Animals must get Ready for Winter
How Plants get Ready for Winter

II. MIGRATION

The Migration of Birds
How Birds find their Way
Other Animals that Migrate

III. HIBERNATION

Warm-blooded and Cold-blooded Animals
Some Animals Hibernate

IV. COLOR THAT PROTECTS

How Some Animals are Protected by their Color

V. WEATHER

What is the Weather?

VI. WHAT ARE MAGNETISM AND ELECTRICITY?

Magnets
Compasses
Electromagnets
Electricity caused by Friction

VII. THE SKY

Stars
The Sun, our Nearest Star
The Solar System
The Story of the Moon

VIII. AROUND US

Light
Heat
Water

IX. PLANTS

How Plants Grow
Herbs, Shrubs, Trees, and Flowers
How Plants find Places to Grow

X. FORESTS

What Forests Do for Us
Caring for our Trees

XI. ANIMALS THAT CHANGE THEIR APPEARANCE

Toad, Frog, and Salamander
The Butterfly and Other Insects

XII. INSECTS

The Place of Insects in Nature
Insects that are Harmful to Man

SCIENTIFIC CONCEPTIONS

There are certain large scientific conceptions which govern the choice of the material placed in Book IV. These conceptions are included here to be used as a guide in the teaching of science. They are not statements to be memorized or even given to children. They are placed here for the teacher's use only:

1. Man's conception of truth changes.
2. Much knowledge remains to be discovered.
3. Conditions favorable to life are likely to persist on the earth for a very long time; no catastrophe for the entire earth is probable for immense periods of time.
4. The earth is very old as measured in terms of our units of time.
5. The surface of the earth has not always had its present appearance and is constantly changing.
6. There have been profound changes in the climates, not only of various regions, but of the earth as a whole.
7. Space is vast.
8. The earth has been developed as a result of the action of natural forces.
9. The sun is the original source of energy for the earth.
10. The earth's position and relation to the sun and moon is of great importance to the life of the earth.
11. All life has evolved from very simple forms.
12. Species have survived because by adaptations and adjustments they have become fitted to the conditions under which they live.
13. Through interdependence of species and struggle for existence, there is maintained a balance among the many forms of life.
14. Life is dependent upon certain materials and conditions.
15. Efficient living is dependent upon knowledge of the principles of health and sanitation.

16. Gravitation is the attraction between bodies. It has profound influence upon the movements of astronomical bodies.

17. The earth and its life are greatly affected by the ocean of air which completely surrounds it.

18. In industry and in the home, man can accomplish more in less time by the use of machines.

19. The applications of electricity and magnetism in the home and industry have revolutionized the methods of living of many people.

SUGGESTIONS FOR PROBLEMS IN GENERAL

In connection with the work planned for the fourth year of science, teachers should familiarize themselves with the teaching aids available in their locality. Trips to near-by hills, streams, parks, museums, and so forth will be very valuable because they furnish first-hand experiences for children.

Many times trips are impracticable, and in such cases the teacher must depend upon other sources for illustrative and teaching material. Many schools have access to museum and library loan collections. Other schools own their own slides which will prove a very fine aid in teaching.

The state departments of education have much free material to lend. The authors suggest that each teacher write to her respective state department as well as to the national department at Washington to ascertain what material is available from these two sources.

If your school does not have access to a museum, you and your children will have a fine incentive to start a permanent science museum yourselves. The children will become enthusiastic over the project. Such a museum should not be a casual matter, but rather a long-time project extending over a number of years. Each year a unit or two could be added. Individual classroom museums might well contribute to the permanent school collection.

Each problem has a section called *Things to Do* and *Things to Think About.* These are designed not as material for examinations, but as study guides to stimulate other questions. Some questions are answered in the text. Others call for further investigation and study, which the teacher will need to encourage. Additional activities are often included in these sections. Much opportunity is afforded for correlation of science with other subjects in carrying out the suggestions given in *Things to Do* and *Things to Think About.*

The value of demonstrations and experiments as teaching aids cannot be overlooked in the teaching of science. Performing the experiments suggested in the various problems throughout the book will help much to clarify the children's thinking. The teacher should carefully supervise all such experiments and *actually do all* those calling for the *use of heat or flame.* It is advisable for teachers to perform experiments alone before they do them with the class.

A general bibliography for teachers' professional use will be found on page 10. Specific bibliographical references for each unit are to be found at the end of the manual. The authors encourage teachers to supplement the text constantly with material gathered from other sources.

As elsewhere stated, teachers are encouraged to change the order of the problems so as best to meet the individual needs of their situations. A caution is inserted, however, that care must be exercised not to omit scientific conceptions which later grades will be building on.

At the beginning of each problem you will find a paragraph or some questions dealing directly with that problem. The purpose of this material is motivation. Teachers may well use this pertinent material to stimulate children to study.

SUGGESTIONS FOR SPECIFIC PROBLEMS

Unit I. The Earth

The Larger Objectives. **1. The earth has three parts: the solid part, the liquid part, and the gaseous part.**

2. Solids may be changed to liquids by heating them.

3. Liquids may be changed to gases by heating them.

4. The great force called gravity is at work all the time.

Problem 1. The Earth and Weight.

I. *Essential meanings for children.* The solid part of the earth is rock and soil; the liquid part is water; and the gaseous part is air. Each part is essential to life upon the earth.

The force called gravity pulls all things toward the center of the earth.

Down is toward the center of the earth, and up is away from the center of the earth.

Gravity gives objects their weight.

Objects which are lighter for their size than water float.

Objects which are heavier for their size than water sink.

II. *Information for the teacher.* The conception that the earth has three parts may be a new one to many children. After the children have read pages 5–19, discuss with them the problem that all three parts of the earth are essential to life.

Children often have wrong ideas, or misconceptions, regarding the earth. They may not consider the air part of the earth. Or again, they may consider the land the entire earth. It is well to emphasize the three parts — land, water, air.

Children often think that the air goes everywhere. This is not true. The air extends into space a distance of probably not much more than a few hundred miles. Beyond that distance scientists think there is no air.

Air is densest near the ground. It gets thinner as one leaves the ground. Breathing becomes difficult as one ascends high mountains because of the scarcity of oxygen. Aviators flying to any great height use oxygen tanks for safety.

Gravity causes the greater portion of the air to stay near the land part of the earth. In fact, most of it is within fifteen miles of the earth's surface. Above that, there is only one twenty-fifth of the whole amount.

Children may wonder why it is colder on mountain tops than in the valleys. This is due to the fact that the tops of the mountains have so little air and dust to prevent the escape of heat.

Children frequently ask, "What is the sky?" It is not a dome-shaped ceiling, as ancient people often believed. The blue color of the sky is caused by sunlight scattered in every direction by the molecules of the gases of the atmosphere.

Fourth-grade children will no doubt be familiar with the word "gravity," and know a bit about the way this force works. It might be well to relate to them Galileo's work with gravity. Discuss in this connection the people's astonishment that the light object which Galileo dropped from the top of the building fell to the earth as quickly as the heavy object. The length of time an object remains

in the air depends upon the force with which it is thrown. Birds and airplanes can remain in the air only as long as they use sufficient force to overcome the force of gravity.

Let the children discuss what this earth would be like if the force called gravity were to stop pulling. The items listed on page 8 will help the children understand the importance of the force called gravity.

If there is a pair of weighing scales available, let the children experiment with measuring the pull of gravity upon themselves and upon objects near at hand. Make it clear to the children that the pull of gravity gives objects their weight.

When the children do the experiments on pages 12–14 with floating and sinking objects, be sure they understand that objects float because the pull of gravity upon them is not greater than the force of gravity which makes the water push them upward.

Be sure to make clear the reason why a steel ship floats upon water, as explained on pages 16–17. Care should be taken to explain that *air* is not responsible for the ship's floating.

The conception of what determines *up* and *down* will doubtless be new to many. You may want to let the children work with the school globe and locate up and down on different parts of it.

Most children do not know exactly what *up* and *down* mean. They think that *up* is always in the same direction no matter where one is. This is not true, as can be seen by the picture in the text on page 18. *Up* is always away from the center of the earth. *Down* is always toward the center of the earth.

III. *Things to Think About* (p. 19). **1.** In answering this question the children might give any of the following responses:

> The clouds might wander off to the moon.
> There would be no atmosphere around the earth.
> Houses and people might float through the air.
> Water would spill out of the oceans.

2. A boat is lighter for its size than water.

3 and **4.** The answers to 3 and 4 are given in the text.

5. As far as scientists now know there could be no life upon the moon.

IV. *Things to Do* (p. 20). **1.** Let several children do No. 1. Tabulate results each time. Both objects will reach the floor at the same time because gravity exerts an equal force upon each.

2. If they both go the exact distance into the air, they will reach the ground simultaneously.

3. Read the story of Galileo's discovery of gravity in the Book of Knowledge or some other book available to you.

4. The children might keep a weight record for themselves during the year. Those who do not weigh enough could make a *special* effort to observe the health rules given in the text.

V. *Further Activities.* 1. Use a globe and ask children to estimate the amount of earth's surface covered by water.

2. Let the children experiment with objects to determine which ones float and which ones sink.

3. If you dropped a stone from the top of a canyon, where would it go? If there were nothing to stop it, how far into the earth would it fall?

4. Why do water wings hold up the weight of your body when you use them in swimming?

5. Fill an inner tube with water and try making it sink in a tub of water.

***Problem 2.* What the Earth is Like.**

I. *Essential meanings for children.* We live upon the land part of the earth.

We have never gone far from the land part of the earth, either up into the air or down into a mine.

Many scientists believe that the inside of the earth is a rigid mass made up of nickel and iron.

Three times as much of the earth's surface is covered by water as by land.

Scientists believe that the atmosphere goes out into space over one hundred miles.

The atmosphere forms a blanket which goes clear around the earth's surface.

We live at the bottom of this blanket, or ocean, of air.

Clouds are usually within a mile or two of the earth.

II. *Information for the teacher.* In discussing the material in this problem be sure to bring out why each part of the earth is essential to life. The land part for food, shelter, and clothing; the water part for food; the gaseous part for breathing.

Scientists are not agreed as to how far the air goes out into space. Some of them believe it extends about one hundred miles. Others think it goes much farther out into space. Right here is a good place to pause and discuss this important fact — "Our conception of truth changes as increased knowledge throws new light upon old truths." For instance:

People used to believe the earth was flat until Columbus proved that it was round.

Many persons thought that terrible dragons living inside the earth belched forth smoke, flame, and hot lava when a volcano erupted.

The Greeks thought that the sun god rode his chariot across the sky during the day and that the droughts were caused by angry gods.

People used to think a rabbit's foot brought good luck to the person who carried it.

Here again you have an opportunity to emphasize the three parts of the earth. Help the children to see the importance of each part. They may wonder how large the earth is. It is 25,000 miles in circumference and 8000 miles in diameter.

Although true proportion cannot be secured in the drawings suggested on pages 24, 28, and 33, yet the children will see objectively how far man has been able to go down into the ground and up into the air; they will also obtain a conception of the depth of the ocean.

In discussing the inside of the earth you also have another opportunity to illustrate that scientists do not agree as to just what the earth is like inside. Further study may disprove much that scientists now think is true about the inside of the earth.

The inside of the earth has long been a mystery. We know very little about it because we have dug only one mile into it. Most scientists agree that the inside of the earth is rigid; that it is made of nickel and iron; and that it will not cave in on itself.

We live at the earth's surface. Above us is the atmosphere. Gravity will not let objects stay in the atmosphere long. It pulls objects toward the earth.

The atmosphere is an ocean of air. We live at the bottom of it. This ocean of air is like the peel of an apple. It surrounds the earth just as the peel surrounds the apple.

The greatest distance man has flown into the air is ten miles. Dr. Piccard made this record. He used an oxygen tank to supply

him with oxygen for breathing. At present he is making plans to fly still higher.

Children will be interested in what causes fog and clouds. First help them to understand that fogs and clouds are the same sort of thing, except that fogs occur near the ground. Both are caused by the condensation of water vapor in the air. Water is constantly evaporating into the air. The warmer and drier the air, the more rapidly evaporation takes place. When the air cools, the water vapor condenses. This makes the gray color of the clouds and fog. It is hard to see far in a fog because of the condensation of water vapor. Even though clouds look far away, most of them are within one or two miles of the earth.

III. *Things to Think About* (p. 35). 1. Scientists do not know everything about the inside of the earth because they have been unable to get down very far to study it.

2. Here are some of the ideas once believed, but now known to be false.

The earth is flat.
There are serpents at the end of the earth waiting to devour ships and men.
The earth is liable to fall in toward the center.
The moon has people living upon it.

IV. *Things to Do* (p. 35). The following are the correct words to be placed on the dotted lines:

1. *Three.*	4. *One.*	7. *One hundred.*
2. *Food, clothing, shelter.*	5. *Three.*	8. *Gravity.*
3. *Eight.*	6. *Atmosphere.*	9. *Gaseous.*

V. *Further Activities.* 1. Fill two dishes of the same size with water. Place one in a cold place and one in a warm place. Watch them. Which one becomes empty first? Why?

2. Wet two towels. Hang one over the radiator and the other in a cool place. What happens?

3. Boil some water in a teakettle. Why can't you see anything just at the end of the spout, while a bit away from it there is a white cloud? What is the white cloud?

Problem 3. Solids, Liquids, and Gases.

I. *Essential meanings for children.* There are three states of matter — solid, liquid, and gaseous.

By heating a solid you can turn it to a liquid.

By heating a liquid you can turn it to a gas.

By cooling a gas you can change it to a liquid.

By cooling a liquid you can change it to a solid.

Things change their state at varying temperatures; that is, ice melts at 32° F., iron melts at a much higher temperature.

Solids have a definite shape.

Liquids take the shape of the container they are in.

Gases have no shape — they try to fill all available space.

When water freezes, it expands.

II. *Information for the teacher.* The children will best understand by first-hand experimentation that liquids, solids, and gases actually do change from one state to another. They can light a candle, which is a solid, and change part of it to a liquid tallow, and part of it to a gas. The liquid will be visible. The gaseous part will not. Point to the space which appears empty just below the flame. That space, which appears empty, contains a gas formed as the liquid tallow changes to vapor.

They can also change ice to water and water to steam as described in the text, pages 38–39.

It is important here to bring out these facts:

1. Solids may be changed to liquids and gases by heating them.
2. Gases may be changed to liquids and solids by cooling them.
3. Water changes to ice at a temperature of 32° Fahrenheit, and to steam at 212° Fahrenheit.
4. Other substances do not change their form at this temperature. Steel requires a much higher temperature than 212° Fahrenheit before it changes to a liquid. Alcohol requires a much lower temperature than 32° Fahrenheit before it changes to a solid.

Discuss the differences between solids, liquids, and gases as given in the text, pages 42–43.

The fact that some objects melt at a high temperature and others at a low temperature is significant. Suppose iron melted at 32° Fahrenheit as ice does. Could it be used for skyscrapers if it did?

Water needs more room when it freezes. This fact often causes trouble. Car radiators burst when water freezes in them. Unprotected water pipes burst when the temperature gets below 32° Fahrenheit. Sidewalks crack and hump up. Rocks sometimes crack when water freezes in their crevices.

Steel and concrete expand when heated, and contract when cooled. Steel bridges and concrete roads must be built to allow for this expansion and contraction. Concrete roads are built in sections or blocks with a space separating the blocks. This space is filled with tar. When the weather becomes hot, the concrete expands and the tar is forced up to make room for this expansion.

One very hot day in New York three swing bridges could not swing back into place because of the expansion of the steel. Traffic was held up until the steel contracted again.

III. *Things to Think About* (p. 46). 1. When watery liquids freeze they expand. That is why the cap of the bottle was pushed above the top of the bottle.

2. Steam is a gas. Many gases are invisible.

3. Water can change from liquid to ice, or to steam. It turns to ice when the temperature goes down below 32° Fahrenheit; it turns to steam when the temperature rises above 212° Fahrenheit.

4. If water froze at 60° Fahrenheit, we should have to use alcohol in our car radiators much longer each year; streams would be frozen over a longer time; and our swimming season would be very short. If iron melted at 100° Fahrenheit, all our steel buildings, trains, cars, and bridges would melt down in the summer time and flow away as water flows in the rivers.

IV. *Things to Do* (p. 47).

1.

Solids	Liquids	Gases
ice	water	steam
cloth	milk	oxygen
blanket	alcohol	carbon dioxide
chair	cream	nitrogen
board	cider	hydrogen
paper	vinegar	helium

2. Let the children do the experiment described in the text. The pan of water will begin to freeze at 32° Fahrenheit. The more alcohol there is in the water, the lower the temperature will have to be to freeze it.

3. The woolen cloth kept the sun's heat from melting the snow rapidly.

V. *Further Activities.* 1. Partly fill a glass jar with water. Mark the height of the water in the jar. Set it outside to freeze on a cold day. Notice the height of the ice in the jar. Does it correspond with the water mark you placed on the jar? When water freezes does it contract or expand?

2. Fill a large pan with snow. Melt the snow. Does the water take as much room as the snow did?

3. Notice when concrete roads and sidewalks are built. Are they built in cold weather, or in hot weather?

Unit II. The Changing Earth

The Larger Objectives. **1. The earth has not always looked as it does now. It has changed its looks many times.**

2. The earth is very old.

3. Certain forces are constantly at work, changing the earth's appearance.

4. The earth has two movements — rotation on its own axis, and revolution about the sun.

5. The shape of the earth is approximately a sphere.

Problem 1. How the Earth Moves.

I. *Essential meanings for children.* One complete rotation of the earth upon its axis takes twenty-four hours, or one day and one night.

One complete revolution of the earth about the sun takes about three hundred and sixty-five days, or one year.

Only half of the earth receives heat and light from the sun at any one time because the earth is not transparent.

II. *Information for the teacher.* Unquestionably, the elementary-school teacher will find it advantageous to teach the facts regarding the position of the earth in space and its relation to other bodies in the sky. Instead of cramming all of it in the sixth grade, a gradual accumulation of experience from grade to grade is advisable.

Until rather recently we thought that the sun did not move. Now we believe the sun moves in space. There are bodies in the sky besides the earth which move about the sun. Each such body has its own path, and each rotates as it revolves around the sun. Some rotate many times while making one trip about the sun. We

see different constellations at various seasons because of the revolution of the earth.

It is well at the outset for everyone to get the two movements of the earth in mind. They affect us.

a. Rotation, or spinning around on an axis.

b. Revolution, or turning around the sun.

Make sure that the children understand that these two movements are occurring simultaneously; that while the earth revolves about the sun once every year, it rotates on its axis every day. In other words, make it clear that it takes only one day of twenty-four hours for the earth to make one complete rotation on its axis, while it takes about three hundred sixty-five days for the earth to make one complete revolution around the sun.

The schoolroom globe might well be in constant use during these discussions. Let the children rotate it on its axis. Let them revolve it around some object which they call the sun. In this connection be sure they rotate it counterclockwise, as illustrated in the text on page 54, since the earth turns to the left, *not* to the right — from west to east, *not* east to west.

If you rotate the globe so that New York gets daylight before California, you will be rotating it counterclockwise. If the sun rises over the Atlantic Ocean for New York, then you are rotating the earth the right way. The sun rises in the east.

Lead the children to see that, because the earth is round, only one half of it can receive light from the sun at any one time. They will thus see why we have day and night. They can find places opposite each other on the globe and note that while New York, for instance, is having day, Peking, which is opposite New York, is having night.

In connection with the revolution of the earth about the sun make sure that the children understand that during one complete trip of about three hundred sixty-five days we have had the four seasons, spring, summer, autumn, and winter. These seasons are due to the earth's inclination on its axis and its position relative to the sun. (For a fuller discussion see Book V of this series.) Since the whole question of what causes day and night was given considerable space in Book III, the purpose of including it here is repetition, as well as tying it up with the revolution of the earth, the topic now under consideration.

When discussing the gravitation of the sun, it might be well to bring out the fact that the gravitation which the sun has is greater than that of the earth, because the sun is so much larger than the earth.

Be careful not to give the children the impression that the sun does not move. While the earth is revolving about the sun, the sun is moving through space.

III. *Things to Think About* (p. 57). 1. Answered in the text.

2. The moon can give us only reflected light from the sun. It has no light of its own.

3. The sun represents the fire. The earth is the giant roast rotating on the spit.

4. Half of the earth is always dark because the earth is round.

5. It takes twenty-four hours for the earth to make one complete rotation.

6. The earth travels about 1040 miles an hour at the equator.

7. The earth is so large that you cannot tell that it is moving so fast.

IV. *Things to Do* (p. 58). 1. Let the children locate cities and countries which are opposite each other. Rotate the globe about a play sun. They will readily see why we have day and night.

2. If we had daylight all the time —

The earth would get very warm.

The earth would have no chance to cool off.

Plants would get too much heat.

Water would evaporate very rapidly.

We should be uncomfortable.

V. *Further Activities.* 1. Associate our habits with the sun. We eat breakfast and go to school when the sun is in the east. We eat lunch when the sun is above us. When do we eat supper?

2. Fix the fact that the sun rises in the east and sets in the west. Let children use their compasses to verify these facts.

3. Discuss the reason for longer days in the summer and shorter days in the winter. Let the children record the time of rising and setting of the sun. Verify this information with a newspaper weather report.

4. On cloudy days have the children point to the place where the sun should be.

Problem 2. **How Old is the Earth**

I. *Essential meanings for children.* The earth is very, very old.
No one knows exactly how old the earth is.
The earth has changed its looks many times.
Volcanoes helped the earth collect an atmosphere.
The earth is constantly being changed by erosion and weathering.

II. *Information for the teacher.* The whole question of how old the earth is, is a fascinating one to children. Make them understand that scientists do not know how old it is. It is so old that no one really knows just how it was formed. The following theories are accepted by many.

Through the ages that man has lived on the earth, he has had some explanation for the formation of the earth. These explanations were in the form of stories or myths. Not until recent years has there been any attempt to arrive at an explanation in a scientific way.

The following explanation is that given by Chamberlain and Moulton of Chicago, and is widely accepted today, although it does not explain some things satisfactorily. Scientists are still searching for other and better explanations.

The information given here is to be used as a background for the teacher and should not be taught to fourth-grade children. A full description of how the earth was formed is given in the sixth-grade book in Pathways in Science.

Our sun is one of the stars that are all around us. It is believed that millions and millions of years ago, the star that is our sun and another star were approaching each other as they moved through space. For thousands and thousands of years they had no effect upon each other, but finally the time came when the force of gravitation became noticeable. Great mountainlike tides of gases were pulled up on the star that is our sun. As the two stars approached still nearer, the force of gravitation became stronger and great masses of hot gases were pulled out from our sun. For some reason the two stars did not crash into each other, but passed and continued in their movements through space. As a result of this, some of the hot gases were pulled back into the sun, but other great masses of hot gases whirled off into space. One mass became the earth, another mass became Jupiter, and so on.

As they separated, these new masses of hot gases whirled on in orbits of their own.

Another, and perhaps the most recent theory, is that of an exploding star. Time only can tell whether this will prove more satisfactory than the others. This theory begins with a star, which was acted upon by certain electrical forces so that the star began to spin faster and faster. It began to bulge and so tremendous were the forces acting upon it, that it finally broke in two parts. Each part was pushed from the other by the energy from the blinding light of the broken star. One part became our sun, and the other was lost in space.

When the star exploded, various masses of hot gases were hurled off which finally became the planets. From this point the story follows the same lines as those of the first theory given.

The new earth whirled on in an orbit entirely its own. It is thought to have been much smaller then than now. Through the ages particles of dust fell to the earth and added to its size and weight. These particles, or planetesimals, were of different sizes and, in the beginning, were numerous. The planetesimals were formed from the clouds of hot gases pulled from the sun, but which were too thin and scattered to form into spheres like the planets.

Later the gases forming the atmosphere collected around the earth.

The earth is now thought to be many millions of years old. In the beginning its surface was bare and desolate. Then the atmosphere was collected, water appeared, and rocks became worn down and broken up by wind, water, and changing temperatures. An environment suitable for living plants and animals gradually appeared.

Children will enjoy trying to make a movie of The Story of the Earth. Some of the pictures would show —

The earth falling from the hot sun.
The earth cooling off.
The first plants.
The giant ferns and trees.
How coal was formed from the ferns and trees.
The first animals by the seashore.
The dinosaurs.
The mammoths.
The Ice Age.
The coming of man.

III. *Things to Think About* (p. 65). 1. The earth is millions of years old.

2. The earth got its atmosphere from volcanoes.

3. When water vapor condenses it falls to the ground. In warm weather we have rain. In cold weather the moisture in the air condenses into snow.

4. No animals lived on the earth at first. Later sea animals, shell fish, dinosaurs, and mastodons appeared.

5. The sun is older than the earth.

6. The stars are older than the earth.

7 and 8. Plants and animals need the oxygen of the air in order to live.

IV. *Things to Do* (p. 65). 1. Take the children to a stream, if possible. Let them find smooth stones. These have been there a long time. They have been worn smooth by the water.

2. Use Washburne's "Story of the Earth," Reed's "The Earth for Sam," and Book VI of this series.

3. This picture would have no people, no skyscrapers, and no houses. It would have just land and water and giant ferns and dinosaurs.

V. *Further Activities.* Read Washburne's "Story of the Earth." Find out what the Greeks, the Egyptians, and the Vikings believed about the formation of the earth.

Visit a museum of natural history to see skeletons of prehistoric animals.

Unit III. The Air and How It Works

The Larger Objectives. **1. The ocean of air about us presses with force against all objects.**

2. The air is important to life.

3. Air is composed of gases, of which oxygen, nitrogen, carbon dioxide, and water vapor are the most important.

Problem 1. **The Air We Breathe.**

I. *Essential meanings for children.* Air is made up of gases.

Oxygen, nitrogen, carbon dioxide, and water vapor are in the air.

Air is about one fifth oxygen and four fifths nitrogen.

Oxygen is necessary to life.

Oxygen makes things burn.

II. *Information for the teacher.* Air is made up of gases. The most important gases are:

Oxygen: about one fifth,
Nitrogen: about four fifths,
Carbon dioxide: only a very little.

Besides these gases, there is also water in the air. Some days there is a great deal of water. Other days there is only a little. When there is a great deal of moisture in the air we then say the humidity is high. It is a muggy day. We feel less ambitious. Usually we expect a storm. At such times the barometer indicates low pressure. We say we are in a low-pressure area.

On clear sunny days we are in a high-pressure area. The barometer reading is high. We feel invigorated and ambitious.

When the moisture in the air condenses, we have fog, rain, snow, or sleet. This condensation is due to the cooling of the air, which cannot then hold all its water vapor. Warm air can hold more moisture than cold air.

There are several ways to prove that the air has water vapor in it. A child who wears glasses has to wipe the condensed water vapor from them when he comes into a warm room from outside. The air next to the glasses was cooled quickly and dropped its moisture.

On hot days, moisture often forms on the outside of a water pitcher filled with cold water. The same explanation as that just given holds here.

Besides these gases and water, there is also dust in the air. The children may see particles of dust by looking at a ray of sunlight.

Oxygen is important to us because we use it in our bodies. We breathe it into our lungs. From there the oxygen goes into the blood and then through the arteries to every part of our bodies.

Plants also take in the oxygen. Children and adults often think that plants do not use oxygen. They confuse the respiratory process of the plant with the food process. Plants take in oxygen through the pores of their leaves. They use the oxygen.

Again, this whole explanation should not be given to young children. The point to be emphasized is that plants go through a process of respiration similar to that of animals, in which oxygen is used.

Respiration is not simply the act of breathing. It is the releasing of energy by the combining of carbohydrates with oxygen in the cells. This takes place in every living cell of plant or animal.

Plants present a large surface, and each cell may come in contact with the oxygen in the air. Thus plants do not need a special mechanism, like our lungs and a circulatory system, such as animals have for carrying oxygen to each cell.

In respiration the oxygen unites with the sugar in the cells and produces carbon dioxide and water.

In respiration oxygen is taken in, energy is released, and the temperature is raised.

Nitrogen by itself cannot be used by plants; it must be in combination with something else. Hence plants obtain their supply of nitrogen from the soil through their roots.

It might be well to talk about methods of extinguishing fires in cases of emergency in connection with the need of oxygen to keep fire burning. The wrapping of a burning object in a blanket or rug, thus cutting off the oxygen supply, has saved many persons from burning to death. Fire needs oxygen in order to burn. As soon as the supply of oxygen is exhausted, the fire goes out.

III. *Things to Think About* (p. 110). 1. Answers to questions found in the text:

a. Fire needs oxygen in order to burn. The sand shuts out oxygen.

b. There is more nitrogen than oxygen in the air.

c. A gas is a state of matter; you cannot see most gases.

d. Plants use carbon dioxide to make food.

e. Oxygen.

f. Oxygen.

2. Dust with an oiled cloth so that the particles of dust will stick to the cloth.

IV. *Things to Do* (p. 111). 1. The words below are the correct ones to use on the dotted lines.

a. Gases.

b. Oxygen, nitrogen, carbon dioxide.

c. Nitrogen.

d. Oxygen.

2. The lighted candle goes out when the supply of oxygen in the glass becomes deficient.

V. *Further Activities.* 1. Light a stick and move it rapidly through the air. Note how rapidly it burns. The effect of moving a fire around in air is to make it burn faster.

2. Ignite a bit of paper in a metal container. Cover it with sand. The fire goes out immediately because no oxygen can get through the sand.

3. Make a list of don'ts about fire, as

> Don't run if your clothes catch on fire.
> Don't keep matches in a warm place.
> Don't play close to a bonfire.
> Don't play with gasoline or kerosene.

4. Every second of the day $10 in property is destroyed by fire. Every minute two fires start in the United States. Every hour two lives are lost and seven are injured by fire. Ninety per cent of all fires are due to carelessness. Think about these facts.

5. Write to the Forest Preservation Department at Washington, D.C., to find out what the United States is doing to prevent forest fires.

6. Place a small drinking glass over one lighted candle and a fruit jar over another lighted candle simultaneously. Why does the candle under the fruit jar burn longer than the one under the drinking glass?

7. To prove that the air we breathe out of our lungs has not as much oxygen in it as ordinary air do the following experiment. Place a drinking glass over a lighted candle. Time the candle to see how many seconds it burns. Now breathe into another drinking glass the same size as the first. Place it over a lighted candle. Time it again. The candle should burn slightly longer in the first drinking glass because there is more oxygen in that air. Oxygen aids burning, but carbon dioxide does not.

***Problem 2.* How Air Becomes Wind.**

I. *Essential meanings for children.* Cold air expands when heated.
Cold air pushes warm air up, thus causing wind.
Air expands when heated.
Wind works for man.

II. *Information for the teacher.* Do the experiment as suggested in the text on pages 113–116. These experiments will show clearly the movement of air. Cool air, being heavy, falls to the earth and pushes the warmer lighter air up.

Make a list of all the ways man has found air useful to him, such as:

Blowing sailboats across the ocean.
Turning windmills to pump water.
Carrying seeds about from place to place.

Be sure the children understand that when air is warmed it expands and is pushed up by the colder air about it. This unequal heating of air sets up air currents, causing wind.

Train the children to observe the weather conditions before and after a storm. They will note that after a heavy storm the air is cooler. They should know that when there is a heavy wind storm the air has been cooled very quickly.

When warm air rises, it contains a great deal of moisture. Rain falls to the earth when this moist warm air is cooled. After a storm there is a period of cool clear weather caused by dry air falling from upper regions.

III. *Things to Think About* (p. 119). 1. Sudden cooling or heating of air makes strong winds.

2. Winds are not so certain as machine power.

3. Take the temperature of your room at the ceiling. Take the temperature near the floor. The floor temperature will be slightly lower.

4. Ventilate rooms by opening windows top and bottom. This lets air circulate in at the bottom and out at the top.

IV. *Things to Do* (p. 119). 1. Harmful things wind does:

Wind blows down trees.
Wind blows down homes.
Wind wrecks ships at sea.
Wind blows grain fields down.

2. Helpful things winds do:

Winds make ships sail.
Winds pump water.
Winds cool you in hot weather.
Winds ventilate your homes.
Winds regulate the temperature of your homes.
Winds scatter seeds about.

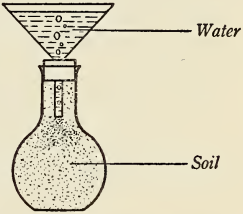
3. Shown in text page 117.

V. *Further Activities.* 1. *How to make wind with a medicine dropper.* Cut some paper into small bits. Put them on the table. Hold the

open end of the medicine dropper near the paper. Press and release the rubber bulb. The paper will blow about. It will stick to the end of the dropper. You made wind by pressing and releasing the bulb.

2. Examine your vacuum cleaner. It makes wind with an electric motor. The wind forces the dust into the bag.

Lead the children to wonder whether there is air in water and in soil. Prove to them by the following experiments that both contain air.



3. Set up the apparatus as shown. Fill the flask with dry soil. Fill the funnel with water. Shake the flask gently. Watch the air bubbles come up through the water and escape into the air.

4. Fill a glass with cold water. Let it stand for an hour in a warm room. What forms along the sides of the glass? Is there air in water?

5. Is there air in soil? Put a lump of soil into a glass of water. You will see air bubbles rising through the water.

6. Here is a simple completion test for children to test themselves on:

a. _______ air rises because it is lighter than _______ air.

b. Air at the ceiling of a room is usually _______ than air down at the floor.

c. _______ is needed when you want a fire to burn.

d. Air is found in _______ and _______.

e. Strong winds are due to _______ heating or cooling of the air.

Correct words for the spaces are as follows:

a. Warm, cold.
b. Warmer.
c. Oxygen.
d. Water, soil.
e. Rapid.

7. Have the children observe the different ways of telling the direction of wind; by smoke, flags, weather vanes, leaves on trees, moistening the finger and holding it away from the body.

8. Keep a weather chart. See if you can determine the wind that brings rain; the wind that brings clear weather.

Unit IV. Social Life among Animals: Man, Bees

The Larger Objectives. 1. Some kinds of animals live in communities and coöperate with one another.

2. Species have survived because by adaptations and adjustments they have become fitted for the conditions under which they must live.

Problem 1. How People Live and Work Together.

I. *Essential meanings for children.* Man is a social animal.

Man lives in a complex society.

Each one is dependent upon others for many things he enjoys and uses.

Other animals, besides man, are social.

II. *Information for the teacher.* Any animal is said to be social if many adults of both sexes of that species live in a single community with their young. In such cases each shares a certain responsibility to all.

Man is the highest of the social animals. He has built up a complex and interdependent society in which he lives. Each member of a society shares a responsibility for every other member. It would be almost impossible for one to live entirely unto oneself.

Let the children compare the life they live with one they might live if they were put on an island entirely cut off from the rest of the world. Make them conscious that all their food, clothing, and shelter would have to be provided by them. There would be no baker or milkman or carpenter on hand to work for them.

Community life has helped man to survive down through the ages. By working for one another men have found the struggle for survival less intense. From the time of the Cave Man to the present, they have overcome great odds to survive famine, cold, fire, floods; wars have not blotted out the species.

Many of the lower forms of animals lead a social life. Some of these animals, such as bees, ants, and beavers, have an elaborate community life. Others live together only at certain times, such as the migration period, the mating season, when there is a scarcity of food, or in time of danger. The following problems tell about the lives of some of the social animals.

It is the author's purpose here to use human society as the highest type of community living. The idea is to bring the children to

realize how complex our community life is. Then, as they study the other social animals, human society will give them a basis of comparison. Among other animals stress the highly social life of the honeybees, the ants, and the beavers as types, comparing them with our own society.

III. *Things to Think About* (p. 130). 1. The following people probably worked for you: the baker, the milkman, the farmer, the grocer, your mother, and so on.

2. The mail clerk, the mail collector, the stamp canceller, the train clerk.

3. We do less for ourselves than our grandparents did for themselves.

5. Other health rules:

Do not spit on the floors or sidewalks.
Keep yourself clean.
Do not put other children's pencils in your mouth.

IV. *Things to Do* (p. 130). 1. You are protected in the city by

Traffic officers.	Fire laws.
Health Officer.	Traffic lights.
U. S. Food Inspector.	Garbage regulation.

2. Country people help one another

Plant and harvest crops.
When ill.
In case of fire.
In case of accident.
In corn-husking bees.
In barn raisings.

3. You would have to

Gather your own food.
Prepare your own food.
Build your own house.
Gather your own fuel.
Make your own clothes.
Build your own ship.
Make your own calendar.

V. *Further Activities*. 1. The next time you visit in the country, notice all the things that country people do for city people.

2. Find out how water is supplied to your city.

3. Tell how garbage is cared for in your community.

Problem 2. Life of Honeybees.

I. *Essential meanings for children.* Honeybees have a highly organized society just as man has.

Honeybees coöperate with one another.

Coöperation has helped the honeybees to survive.

Honeybees are the most social species of bees.

There are three kinds of bees in a hive — queen, drones, and workers — each having a definite job to do.

II. *Information for the teacher.* Honeybees are highly social. They offer an interesting example of coöperation and interdependence. It is suggested that you secure an observation beehive from A. I. Root Co., Medina, Ohio.

This hive containing bees costs about ten dollars. Place it near a window. Raise the window about three inches. Fit a board tightly into the open space. Bore a hole in the board opposite the opening at the end of the hive. Fit one end of a metal or glass tube into the opening of the hive and the other end out through the hole in the window board. This allows the bees to come and go in and out of doors at will. The case has wooden sides fitting over glass sides. When the bees are not being observed, keep the wooden sides on, since bees work better in the dark.

If there are plenty of flowers near by the bees will make enough honey to supply themselves with food. However, where food is scarce and during the winter, it is best to introduce fresh combs of honey into the hive. It is best not to have many children present at this time. Dampen some folded pieces of paper and set fire to them with a match. They will make a smudge. Hold the smoking paper near the ventilators at the bottom of the hive. The smoke will go into the hive and stun the bees. The honey may then be inserted at the top without danger that the bees will sting anyone.

It is well to keep a small damp sponge inside the hive to supply water to the bees.

It is difficult to keep these bees over the winter; but, if properly cared for, the hive can be kept alive. By lengthening the tube leading from the hive to the outside, the beehive can be set farther away from the window. Since bees in this kind of hive cannot store enough food for winter, it is essential that they be supplied with plenty of honey from outside.

Although this work with bees will be more meaningful if there is opportunity for first-hand experience with such a hive, it does not follow that the study of bees cannot be entered upon without the observation hive. It can be.

There are three kinds of bees in the hive, as shown on page 135. If you have an observation hive, try to find the three kinds. The long yellow one is the queen, the short ones are workers, and the big fuzzy fat ones are drones.

In the beehive the activity centers around the queen bee. She has her circle of guards, who attend her at all times. She lays the eggs which hatch into baby bees. During the laying season — spring and early summer — she may lay as many as three thousand eggs in one day. Except for mating and swarming, the queen never leaves the hive.

The queen is carefully cared for by the workers. They guard her at all times. She is fed by the workers. They place food upon her short tongue for her. In time of swarming she finds her soldiers among the workers.

The second type of bee found in the hive is the drone, or male bee. His life is quite different from that of the queen. He is a gentleman of leisure. While the queen is working, the drone lies about. Drones are fed by the workers, as their short tongues are not adapted for gathering nectar. The drones have no means of protection, being without a sting. Their one function is to mate with the queen. During the summer they are well cared for by the workers. In the fall, when food becomes scarce, the drones are driven out of the hives and, since they are quite helpless, they die.

The worker bees are, of course, the most numerous in the hive. They are rightly named. It is often said they die of fatigue. The average length of a worker's life is six weeks.

These worker bees perform many functions. One important duty is to provide nectar and pollen for the hive. The nectar is made into honey and the pollen into beebread. These bees gather nectar by means of their long tongues which they insert into the nectar cups of the flowers. The nectar is stored in their honey sacs. A honey sac holds only about three drops of nectar. When the sacs are full, the bees fly to the hive and store it in the wax cells which other worker bees have provided for them. The nectar then thickens because some of the water evaporates.

When the honey is of the proper consistency, the workers put little wax caps on the cells.

As the workers gather nectar, they also get pollen. This pollen is combed into the pollen baskets on the hind legs of the workers. By mixing the pollen with nectar, a food called beebread is produced. Beebread is fed to baby bees. It is stored in wax cells just as honey is. The honey is stored in the honeycomb, while beebread is usually stored in brood comb.

Some worker bees act as guards of the hive. They stand about the entrance to the hive and watch for enemies or strangers. Bees from other hives are not welcome. Just how the guards distinguish them is not known, but some suggest that bees of different hives may possess a characteristic odor. At any rate the sentinels spot enemy bees and a struggle follows, each trying to sting the other.

The worker bees also act as nurse bees, feeding and caring for the larvæ in the hive. They place beebread on the tongues of the young with their own tongues.

Workers keep the hive clean and sanitary. They remove any dirt that gets into the hive. Should a bee or any enemy die in the hive, the housekeepers remove it. Sometimes mice or grasshoppers or even birds die in the hives. These animals are too heavy to be rolled out, so the workers seal up the body into an air-tight compartment made of a sort of resin called propolis.

The hive is ventilated by the fanning of workers' wings. These workers station themselves in rows in the hive. In case of terrific heat the fanners cause a current of air to pass through the hive. Some authorities believe that they have a regular system of relieving the fanners on duty at certain intervals.

Worker bees also make the wax they use for making cells. They gorge themselves with honey and then hang themselves up in rows at the top of the hive. Tiny wax scales ooze out of the under sections of the abdomen. The bees scrape the scales into their mouths, and when the wax is properly mixed with fluid, it is ready to be shaped into hexagonal cells.

The cells are used for two purposes. Part of them are used for storing honey and beebread. Others are used as cradle cells for the eggs which the queen lays. These eggs hatch into larvæ in three or four days. In about eighteen more days the larvæ emerge as full-grown bees.

The cells that queens and drones hatch from are larger than the cells which hold worker eggs. A queen cell is the largest. When the queen larva hatches, it is fed on royal jelly, a special food which makes the queen grow to a large size.

As soon as a new queen hatches, the old queen tries to kill her. However, each queen has an army of soldiers. Usually the old queen and her army leave the hive in search of a new hive.

III. *Things to Think About* (p. 151). 1. Because honeybees supply men with honey.

2. Worker bees do the following for other bees:

Gather nectar and pollen.	Feed the babies.
Make wax.	Fight enemies.
Clean the hive.	Protect the queen.
Ventilate the hive.	Guard the hive.

3. The queen lays all the eggs; so she must be protected in order to perpetuate the hive.

4. Eyes help the bees to see flowers, to see danger, and to locate a new hive when swarming.

5. Two hives are formed where once there was but one, and more bees are hatched. Thus bees never die out.

6. Bees do the following things to keep healthy:

Clean the hive.	Drag out dead enemies.
Ventilate the hive.	Drag out dead bees.

IV. *Things to Do* (p. 152). 1. If you have access to a compound microscope, use it to examine the bees' eyes, sting, pollen baskets, and so on. If not, use a magnifying glass. Draw pictures of what you see.

2. Visit an apiary, if possible.

V. *Further Activities.* Write to A. I. Root Co., Medina, Ohio, for their free material about bees.

Invite a beekeeper to bring an empty beehive to school and show you the inside of it. Ask him to tell you how he dresses when he is removing the honey.

Read Morley, "The Bee People." It tells many interesting things about bees.

Buy some beeswax, and examine it closely. It is used to wax flatirons and to wax thread. See what it does to thread. Ask mother what it does to her iron.

Unit V. Social Life among Animals: Ants, Wasps, Spiders

The Larger Objectives. 1. Some kinds of animals coöperate with one another.

2. Ants and some wasps have social habits which resemble the social habits of the honeybees.

3. Social animals have probably been better able to survive down through the ages than solitary animals.

Problem 1. Life Inside an Ant Hill.

I. *Essential meanings for children.* Ants have a social life somewhat like that of honeybees.

Ants coöperate in their work.

Ants have queens, drones, and workers just as bees have.

There are many species of ants.

Termites are sometimes called white ants. They are not true ants.

Ants are true insects; that is, they have three body parts and six legs.

II. *Information for the teacher.* Take the children to the park or the fields either in the fall or early spring, and secure a colony of ants to bring back into the schoolroom. Dig up the hill, making sure to get a queen, a quantity of ant larvæ, and pupæ. The larvæ will look like rice grains. The eggs are small white grains. Place these in a glass jar. Set the jar in a shallow pan containing a bit of water. The jar can then be uncovered, and, since the ants cannot swim, they will not be able to leave the jar. Make sure the jar does not touch the side of the pan. A commercial observation ant box may be bought from Austin Workshops, Hanover, Mass., at the approximate cost of one dollar.

To feed the ants place crumbs of bread, cake, or shreds of meat in the jar. Some of the crumbs should be dipped in honey. Feed the ants sparingly every four or five days.

Ants work better in the dark. If they are kept in a dark place or covered with a dark cloth, provided the cloth does not offer a means of escape, they will build tunnels faster.

With a schoolroom ant colony the children may observe the following habits of ants:

How they build their tunnels.
How they carry eggs and larvæ about.
How they stroke one another for food.
What the difference is in looks between the queen, the soldiers, and the workers.
How the ants coöperate in their living.
How they keep the nest clean.

Keep comparing the social life of the ant with that of the honeybee and of man. Make the children conscious that ants resemble bees in many ways. Lead the children to see the advantages of a social life. List these advantages as follows:

1. It helps them to protect one another.
2. It helps them to provide food for one another.
3. It makes perpetuation of the species possible.
4. It means less work for any one ant.

Ants are distributed all over the earth except in very cold places, such as tops of high mountains or in polar regions. They are found in great numbers in forests, prairies, deserts. They have survived since very ancient times, withstanding hardships and multiplying constantly. Wheeler says there are 3500 species of ants.

Most ants nest in the ground. They build halls and chambers. The chambers serve as storehouses, fortresses, and nurseries. The rooms nearest the top are used to store the eggs about to hatch. The queen cell is at the bottom of the hill for safety.

In a colony there are several kinds of ants. The queen is the largest in the hill. The males come next. Then there are soldiers, or large worker ants, that guard the colony. Then there are smaller workers that act as nurses to the baby ants.

After a queen makes her wedding, or mating, flight, she returns to the ground and bites off her wings. She then seeks a home. Sometimes she uses a hill already made. Other times she makes a small new hill. Sometimes she lays her eggs in a cavity under a stone. The first ants that hatch are fed by the queen from her own stomach. Should you offer her food, she would refuse it. All these first-born ants are workers. They enlarge the hill, collect food for the queen, and take the responsibility for the second brood of larvæ.

The large red ants often wage war upon the black ants. Scouts are sent out first. Later the whole army goes with the scouts. Usually the army captures slaves and larvæ and pupæ. These slaves all work faithfully for their masters. It sometimes happens that the slaves do so much for their masters that the latter become helpless and perish if something happens to the slaves which kills them.

Ants eat honeydew, which they get from tiny plant lice called aphids. These aphids feed upon the roots and branches of plants. They gather the sap of the plant, which they change into a liquid that ants are fond of. They get their food by stroking the backs of the aphids gently with their antennæ. Ants value these tiny creatures highly. They make tunnels from their hills to roots of plants so that the aphids can secure sap. They let the aphids live with them in their hills.

Ants often beg food from one another by waving their antennæ in the air. Their requests are usually granted. The food is distributed by regurgitation.

Some ants gather seeds of the violet, nettle, oat, and various weeds for food. They store them in the common storehouse.

The marriage flights of the ants occur in the early summer. The males and females emerge on a warm afternoon. They literally fill the air. After mating, they settle down to earth again. The queen bites off her wings and sets to work looking for a place in which to lay her eggs. Many queens perish because they do not find a place to build a nest.

The carpenter ant is one of the largest of our common ants. Its entire body is black. It nests in logs, trunks of trees, and in the timbers of buildings. Often the dead interior of a tree is made into a complicated series of rooms.

The termites, though often called white ants, are not true ants. They resemble ants in social habits. They are found in tropical climates in greater abundance than in temperate climates. These so-called white ants sometimes build mounds twelve feet high. Other species build round reddish nests several feet thick in trees.

The kings and queens are winged insects, while the workers are not. There are two sizes of workers. The smaller class gather food, care for and rear the young, and build nests. The larger class or soldiers guard the next.

After mating, the queen and king return to earth. If they are not discovered by a termite worker they perish because they are unable to provide their own food and shelter.

Termites do not like the light. They build covered ways wherever they go. In tropical countries they are great pests because they feed upon wood, eating through beams of buildings, or furniture, and even library books. They leave only the outside part of the wood, so that a slight weight will cause the object to crash to the ground. Libraries are being built of stone so that termites cannot eat their way into the bookshelves.

Examine the picture on page 168. Notice how the ants build their apartment-house hills. The queen will be found in one of the deepest rooms where she is safest.

Compare the growth of the ant from egg to adult with that of the honeybee.

III. *Things to Think About* (p. 180). **1.** Black, red, carpenter, farmer, white.

2. An apartment house built underground with a hall and rooms leading from it.

3. By fighting the black ants and capturing them.

4. They eat into wood, undermining buildings, destroying furniture, and so on.

5. An ant colony is like a bee colony in the following respects:

Both have a queen, workers, and drones.
Each colony has guards.
Each colony has specialized tasks for its workers.
In each the queen is protected.

6.

Special ants	Special people
Guards	Soldiers
Workers	Workers
Queen	President
Slaves	Hired help

IV. *Further Activities.* **1.** Examine different kinds of ants under the microscope.

2. Compare the body of a honeybee with that of an ant. They both have three body parts and six legs. Are they both insects?

3. Watch for the wedding-flight day. It will come in May or June. The air will be alive with ants. When they come to earth, catch a queen. Put her in a glass and watch the abdomen of her body get large. Eggs are forming inside. She will lay these eggs in the glass. When the larvæ hatch, she will feed them by regurgitating food from her own stomach. Watch them pupate. Then let them go or else feed them so that they will not die.

Problem 2. Life of Wasps.

I. *Essential meanings for children.* Some wasps are social.

Some wasps are solitary.

Wasps are insects.

Some wasps have been better able to survive because they cooperate.

II. *Information for the teacher.* In connection with wasps there is again an opportunity to bring out the differences between social and solitary animals. Keep comparing the social life of wasps with that of the honeybees, the ants, and man.

After a good frost it will be safe to bring an already discovered wasp's nest into the schoolroom for study. The children can see how it is made; how the rows of cells are constructed; how the opening is at the bottom to keep out the rain; how the nest is fastened to the branch or stick that holds it.

Encourage the children to keep a nature museum. Such an activity provides a stimulus for collecting material, as well as a place for children to display the material which they collect.

Make sure that the children understand that the yellow jackets and hornets, or paper wasps, are social, while the mud dauber, mason, and killer wasps are solitary.

The method of capturing food for the young is fascinating to children. Discuss these different methods as discussed in the text. Wasps are not plant eaters as bees and many ants are. They feed upon other insects. Keep on the watch to see a wasp dragging a victim to her nest for her young to feed upon.

As with the ants, the social wasps have three forms of individuals in their colonies — males, females, and workers. The colony exists for only one season. The males and workers die in the autumn. The females hibernate during the winter months and start new colonies in the spring. As is the case in the ant hill, the first eggs

that hatch are all worker wasps. Later the males and females appear. The workers and queen have stings but the drones have none.

Social wasps build their nests in the ground, or attach them to roofs and eaves of buildings or branches of trees. The nests are made of paper composed of bits of wood made into paste by the jaws.

The wasps that build their nests above ground manufacture a gray-colored paper out of the weather-worn wood which they find on trees, fences, and stumps. The paper is very tough. It is also weather-proof.

The wasps that build underground make a fragile brownish paper which would not stand exposure to weather.

There are two sorts of social wasps common in the United States. One is the Polistes, the other the Vespa. To the latter belong the commonly known yellow jackets and hornets. They build round-shaped nests, such as you see on page 182. Inside the nests are layers of comb where baby wasps hatch from eggs. The yellow jackets are savage insects when disturbed.

The solitary wasps build a variety of nests. Some are miners, some carpenters, and some masons. One kind, the mason wasp, makes a neat jug-shaped nest on the branch of a bush or plant. Inside the jug nest it lays its eggs. Then off it flies for caterpillars with which it provisions the nest. The young feed upon these caterpillars.

The mud-dauber can be recognized because of its habit of jerking its wings nervously. These wasps attach their nests to flat stones or to the ceilings of buildings. Each room is about an inch deep. An egg is laid inside each mud chamber. A caterpillar or spider is placed beside the egg to serve as food for the larva when it hatches.

The cicada-killer wasp burrows into the ground to build its nest. The tunnel has rooms in it where eggs are laid. The wasp catches cicadas or locusts to serve as food for the larvæ that hatch.

III. *Things to Think About* (p. 190). 1. Wasps do not store honey as honeybees do.

2. They have to work hard to supply enough food for themselves and their young. All but the queen die in the fall.

3. The first brood of workers help enlarge the wasp nest, gather food, and free the queen so that she can lay more eggs.

IV. *Things to Do* (p. 190). 1. Explained in text.

2. Compare the bodies of wasps, bees, and ants. Look at them under the microscope.

V. *Further Activities.* 1. Examine dead wasps under the microscope.

2. Test the strength of the paper made by wasps. Is it as strong as man-made paper?

3. Test the wasp's paper to see if it is waterproof. Put a piece of it in water. Put a piece of man-made paper in water, too. Which withstands water the better?

Problem 3. **Life of Spiders.**

I. *Essential meanings for children.* Spiders are not insects.

Spiders are arachnids; that is, they have only two parts to their bodies, and eight legs.

A few species of spiders are social.

Most spiders are solitary.

Some spiders spin webs in order to trap their prey.

II. *Information for the teacher.* The section dealing with spiders is divided into two parts — spiders that spin webs and spiders that do not spin webs.

Spiders are not insects. They are arachnids. They differ from insects in that they have only two parts to their bodies, whereas insects have three. Spiders also have eight legs whereas insects have only six.

Most spiders are solitary; that is, they live and work by themselves. Only three species are social in habits.

The banded spider spins three unique articles — a spiral web, a sheet, and a silk bag. It uses the web for catching its prey. The sheet is used to wrap the victim in. The bag is used to store the eggs in until they hatch.

The spinnerets, or spinning organs of the spider, are near the end of the abdomen. They are fingerlike with spinning tubes from which silk is spun. There are as many as 150 tubes on each spinneret. When the silk is within the body, it is in liquid form, but it hardens as it comes in contact with the air.

Besides these many small spinning tubes, there are a few large tubes used to spin the ordinary thread.

In making webs some spiders use two kinds of thread. One kind is sticky and stretches; the other is dry and will not stretch. If you examine a spiral web, you will find that the lines making the framework are dry and inelastic while the spiral line will stick and stretch.

Spiders use silk to spin webs and snares; to make tents or tubes to live in; to make egg sacs for their babies to hatch in; and for flying machines with which to move about.

The egg sac is made in the fall. In it are deposited 500 or more eggs which hatch in the early winter. In the spring small spiders emerge from the sac.

It is remarkable how some spiders travel miles on horizontal bridges of silk.

The web weavers first build a framework of silk threads, fastening it to near-by bushes or other objects. All these threads radiate from the center. They are dry and will not stretch. Upon this framework is spun in spiral shape a sticky, elastic thread. Sometimes a zigzag thread is added across the center to strengthen the web, as you see on page 193.

Some spiders live in their webs, staying near the center and with the head pointed downward. Others have a hiding place near by and go to the web on a silken thread.

The garden, or banded, spiders are yellow and black. They weave beautiful round web nests in gardens and fields where they capture creatures frequenting such places, such as grasshoppers, flies, and beetles. After the prey is captured, a white sheet of silk is spun around it just for safety. Only the blood of the victim is used for food. The rest of the body is discarded.

The triangle spider gets its name because of the fact that it spins a triangular-shaped web which it fastens between twigs. In the web it catches insects, which it uses as food. After the prey is entangled in the web, this wise spider jerks the web several times just to be sure of its victim.

The grass spiders spin large sheetlike webs upon the grass. The prey crawls under the tent and is ensnared. Leading from the tent is a funnel-shaped tube which conceals the spider. As soon as a victim is ensnared, the spider rushes up the tube to feast upon it.

Jumping spiders do not spin webs. They are found upon fences and in weathered wood. In color they are gray, with white bands and spots. They can move forward, backward, or sideways very rapidly, and can also jump to catch their insect prey.

The crab spiders are found in the white and yellow flowers which resemble their own coloring. They spin no webs, catching their prey as it enters flowers.

The Tarantula family of spiders live in warm climates. They are very large, hairy, dark-colored spiders. They dig silk-lined tubes in the earth in which to hide.

The trapdoor spiders are Tarantulas. They are very interesting because they build such novel houses. The houses are built in the ground, lined with silk, and provided with a hinged door which exactly fits the opening to the house. When not searching for prey, they hide in the houses.

Compare the web of the banded spider with that of a triangular spider. See pages 193 and 197 of the text.

Some of the spiders that do not spin webs are the jumping spider, the crab spider, and the Tarantulas. These spiders are less common. Perhaps you may see the crab spider in your museum. It gets its name from its habit of walking sideways, as many crabs do, to secure food.

The Tarantula is somewhat dangerous, because its poison is strong enough to injure man. All spiders have poison fangs, but the poison of most spiders is usually not strong enough to harm man. It is like a bee's sting. It is advisable not to allow children to handle spiders. Spiders can be kept without letting the children touch them.

Make an insect cage of wire screen. Go on a field trip in search of spiders to put in the cage. Feed them flies. Watch them spin their webs and trap their prey. If you can get a banded spider's silk bag, you will enjoy watching it burst, seeing the babies climb to the tops of the branches and fly away on the threads.

III. *Things to Think About* (p. 205). **1.** Spiders have two body parts; insects have three. Spiders have eight legs; insects have six.

2. The banded spider; the grass spider; the triangular spider.

3. By jumping, trapping them in trap-door nests, and poisoning them.

4. The killer wasp likes spiders.

IV. *Further Activities.* **1.** Feel the two kinds of thread of a web. Some will be sticky; others will be dry. The spiral threads are sticky. The framework ones are dry.

2. Watch a spider at work building its web.

Unit VI. How Other Animals Live

The Larger Objectives. 1. Some animals live together to secure food.

2. Some animals live together to secure protection.

3. Some animals live together to rear and care for their young.

4. Some animals band themselves together to migrate.

5. Some animals are social all the year round, while others are social only during certain periods.

Problem 1. Life of the Beaver.

I. *Essential meanings for children.* Beavers have a social life resembling the social life of bees and ants.

Beavers are mammals; that is, their young are fed with milk which the mother produces.

Beavers live together all of the year.

II. *Information for the teacher.* If you are fortunate enough to live near a beaver colony, make a trip to see their dams, lodges, canals, and the like. Most children will not be able to study the beaver except vicariously, as beaver colonies are not so common as beehives and ant hills.

Beavers are mammals. That is, the young are born alive from the mothers' bodies. During infancy they are fed upon the milk which the mother produces.

Several beaver families, consisting of the father, mother, and six to eight babies each, live together in one colony. They share the responsibility of constructing the dam, lodges, and canals. In case of danger the adult beavers warn the colony by slapping the water with their scaly tails. Because of the great danger of enemies upon land, the baby beavers are kept in the lodges and the pond until they are about a year old. The mother beavers are excellent mothers, guarding their young constantly. Beavers have always interested man a great deal, possibly because beavers, like men, band themselves together and coöperate in various undertakings. Beavers are also very ingenious animals, accomplishing feats of engineering which are remarkable.

The most conspicuous part of the beaver's work is the dam. The main purpose of the dam is to keep a body of water at a constant level in order that the entrances to their lodges may be concealed

and to provide a safe place of retreat in case of attack by an enemy. Dams consist of a number of sticks laid in the water with the butts upstream, weighted down and anchored with sod, stone, and water-soaked wood. At the upper edge of the dam the beavers place sod, roots of grass, and muck. The force of the water works these materials into the network of the dam.

A dam has to be constantly kept in repair. As the pond fills up with water the height of the dam must be increased. Every spring, leaks have to be patched. The ends of the dam have to be reënforced often.

Beavers build different types of lodges. Sometimes a lodge is built partly into the bank and partly in the pond. Often these are the summer abodes of these animals. Such lodges are carefully concealed so as to avoid the danger of intrusion.

The winter abode is usually built right out in the pond. It is about five feet in diameter, and from two to seven feet high. The top of it is dome shaped. In order to build this lodge the beavers must gather twigs and bark and mud. It is strong enough to withstand the severe storms of spring. Each lodge has two stories — an upstairs and a downstairs. The first floor, or downstairs, is about four inches above the water and serves as a drying-off place. When the beavers enter the lodge, they rest here a moment to dry. The upstairs serves as living quarters. They eat and sleep here.

Entrance to a lodge is gained through tunnels which lead to the drying room. There are always two such tunnels to allow for easy escape in case of danger. These tunnels are straight and often long. Where they enter the pond, they are protected by a network of sticks to prevent the burrows from falling in. All entrances to tunnels are under water to add to the safety of the beavers.

The most ingenious bit of work done by the beaver is the construction of canals. If there is an obstruction between the pond and the stream, the beavers will dig a canal. Upon this they float the branches to their lodges. Since beavers are clumsy on land, these canals offer a convenient escape in case of danger. The canals are invariably built where the distance is shortest. They are claimed to be the most remarkable demonstration of skill found anywhere in the animal world other than man's work.

When you stop to consider the amount of trees, branches, and twigs used by beavers you will understand the importance of canals.

Wood is used in building the dam and in constructing the lodge. The bark is used for food.

Beavers are partial to willow, ash, birch, and maple bark. Perhaps you may have noticed that birch trees are often found in abundance near beaver dams and ponds. Trees bordering the bank of the pond are cut first. As this supply gives out, the beavers go farther away. Paths are cleared or canals built to allow for the carrying of the branches.

Beavers have a splendid strong set of gnawing teeth, which enable them to fell large trees. While gnawing, they stand in an upright position balancing themselves on their broad scaly tails.

Beavers have always been sought for by man because of their lovely fur. Wolves, foxes, hawks, and bears are fond of beaver meat. The United States Government protects the beavers against man, but can do little about regulating the activities of the other enemies.

III. *Things to Think About* (p. 219). 1. Beavers gain protection by living together.

2. Beavers' skins are used for clothing.

3. Beavers are very skillful in construction work and the cutting of trees.

4. Beavers can build dams, lodges, and canals.

5. Beavers can be trapped only during certain seasons.

IV. *Things to Do* (p. 219).

Mammals	Insects
cow	grasshopper
elephant	fly
sheep	mosquito
horse	butterfly
dog	beetle

V. *Further Activities.* 1. If you have a beaver exhibit at your museum, be sure to see it.

2. Examine a piece of beaver fur which someone may be able to bring, such as a coat collar or a hat.

3. Write to the Bureau of Biological Survey, Washington, D. C., to find out the law about protection of beavers.

Problem 2. **Animals that Live Together at Times.**

I. *Essential meanings for children.* Many birds band together for migration, thus securing protection.

Buffaloes protect themselves from wolves by uniting to fight.

Many birds live together during the season of mating, and remain together until the young leave the nest.

Some animals unite to capture food. Wolves hunt in packs in order to capture large prey. Pelicans unite to catch fish. Storks unite to catch grasshoppers.

Some animals are solitary all the year round.

II. *Information for the teacher.* This problem deals with animals that are social only part of the year. Obviously there must be some reason for being social at certain seasons and solitary at others.

Some animals unite for their own protection. They are better able to fight enemies. They are able to help one another. The buffaloes of the plains go in herds in order to protect themselves from the attacks of savage wolves. One buffalo fighting alone cannot succeed in combat with a pack, while several fighting together can.

Then, too, some animals, such as the wolves, find it advantageous to travel in packs in order to secure food. A pack of wolves can often attack and kill many reindeer and buffaloes.

Pelicans unite to catch fish by encircling them in shallow water.

Storks unite to catch grasshoppers.

Other animals unite to migrate. The birds that go south in the fall and north in the spring are examples of this type. In the fall flocks of birds congregate and wind their way along the roadways of the air — along the valleys and over the mountains — to the south.

The reindeer of the north migrate in search of food. Whales, seals, and sea lions migrate to get food.

Some animals live together only during the mating season. Many of our circus and zoo animals come in this class. The tigers, lions, jaguars, and pumas unite to rear a family. As soon as the young can shift for themselves, the parents separate.

You have been told that the social habit of animals has many advantages. There are some disadvantages, too. When food is scarce, sharing one's find with a colony is often a hardship. Many animals living together often attract an enemy by the noise and confusion

made. Some animals, such as coyotes, have a strong odor. This odor attracts enemies.

In the animal world there are varying degrees of social life from the most complex social life of man to the simple life of the less gregarious types. Only by constant comparison of one type with another can the significance of this large topic on the Social Life among Animals be realized. Keep it constantly before the children.

III. *Things to Think About* (p. 229). 1. For protection, for securing food, for migration, and for the purpose of rearing a family.

2. Birds, seals, whales, sea lions, and reindeer.

3. Buffaloes and deer.

4. Bears, tigers, lions, and jaguars.

IV. *Things to Do* (p. 229). 1. You may want to make your record on a chart which you can keep for reference for next year.

2 and 3. Check your list with the list you receive from the American Museum of Natural History, New York.

V. *Further Activities*. 1. Watch the birds in the autumn. What ones do you see banding together to migrate?

2. In the spring the warblers will be migrating north. When they are passing through your locality, you will see many of them together.

3. What birds are residents of your locality the year round?

Unit VII. The Value of Animals and Plants

***The Larger Objectives*. 1. Many animals deserve protection because of their value to man.**

2. Many plants deserve protection because of their value to man.

3. Man is dependent upon plants and animals for life.

***Problem 1*. What Animals Do for Us.**

I. *Essential meanings for children.* Animals, especially birds, help to keep a balance of nature.

Most of the birds are deserving of protection.

Before destroying any kind of animal, one should be sure it is really harmful.

One should kill animals only when there is good reason to do so.

Animals give us food, clothing, and shelter.

II. *Information for the teacher.* In this problem the essential thing to get across to children is the value of animals to man. In years past when the country was not so thickly settled, there was but little thought given to the economic value of animals, especially birds. Hunters shot animals by the hundreds for the mere sport of shooting.

Today, however, there has been more serious thinking regarding this problem. It is known that if all birds were destroyed it would be only about seven years, according to one estimate, before all human and animal life on the earth would begin to perish from starvation. If the warfare against the destroying of birds stopped, there would arise such an army of harmful flying, hopping, buzzing, crawling insects that all vegetation would be consumed. Not a tree, or stalk of corn, or blade of grass would be spared. The sun would dry up the barren earth. The winds would fill the air with sand. The rains, unchecked by forests, would wash the bare ground away.

Man always suffers when the balance of nature is upset. In the past, birds were able to increase in numbers over harmful insects. Today, however, harmful insects have the lead. Thousands of dollars' worth of cotton, grain, fruit, and vegetables are destroyed annually by insect pests. The European corn borer, the Japanese beetle, the cotton boll weevil, and the grasshoppers and locusts have multiplied so rapidly that it has been almost impossible to check them in their path of destruction. The government spends great sums of money for such purposes. Not all insects are harmful. Care should be taken to protect the ones that do good.

The ordinary house cat is one of the worst and most destructive enemies of the birds. It is estimated that 100,000,000 nestlings are destroyed annually by cats. Even the best-cared-for cats prey upon young birds.

The draining of ponds, the clearing of forest tracts, trapping and shooting have all taken their toll of bird life.

Children as well as adults have many wrong ideas as to the usefulness of certain birds. They condemn birds that do much good, such as the common grackle and crow. There seems to be only one bird that does more harm than good, and that is the English sparrow. Birds are frequently accused of eating grains and fruits when actually they do not. Many birds eat grain only when insect foods are lacking.

The crow is valuable to farmers. It consumes insects harmful to crops — eating many of them in the early spring before they have a chance to reproduce. Many beetles, white grubs, grasshoppers, and ground beetles are favorite foods for the crow. It does much more good than harm.

Both the tree and song sparrows are man's friends. The tree sparrow devours weed seeds and feeds insects to her young. The song sparrow eats cankerworms, ground beetles, cutworms, plant lice, grasshoppers, and fleas.

The catbird sometimes gets a bad name because of its fondness for fruit. However, it prefers wild fruit to cultivated fruit, and, besides its diet of fruit, consumes quantities of ants, beetles, grasshoppers, and caterpillars.

The robin has come in for its share of complaint from the fruit-growers, especially the cherry-orchard growers. This bird prefers wild to domestic fruit, consuming ten times as much of the former as of the latter. Robins work all season to keep insect pests away from the fruit trees. They deserve their share of the crop. Forty-two per cent of the robin's food is animal matter, principally insects.

The house wren eats about seventy-eight per cent animal food.

Woodpeckers, with the exception of the sapsucker, strip the trees of insect larvæ. Moths, butterflies, grasshoppers, beetles, and ants are devoured.

The blue jay is often accused of feeding upon the eggs and fledglings of his neighbors. Those who have studied the habits of these birds claim that the statement is grossly exaggerated. This trait is undesirable; but one cannot condemn this bird as totally bad, when one finds such pests as the boll weevil, ants, tent caterpillars, and the brown-tailed moth on its list of diet.

The grackle eats one third insect food and almost one half grain food. Its greatest damage is done when it attacks a wheat field. Even so, can one condemn a bird that follows the plow in search of harmful white grubs?

Have the children write to the United States Biological Survey at Washington for information regarding birds of their locality.

In addition to the birds there is to be added the friendly toad who lives almost entirely upon insects and earthworms. Because of its nocturnal habit, it catches night-flying insects that have fewer enemies pursuing them.

The toad patrols roadsides, gardens, fields, lawns, and walks. In twenty-four hours a toad eats four times its stomach capacity. It destroys potato bugs, May beetles, click beetles, cucumber beetles, cutworms, and tent caterpillars.

Snakes cannot be overlooked as aids to man. They eat a countless number of mice and insects. The helpful ones far outnumber the dangerous ones.

Bats are also very useful, for on account of their nocturnal habits they devour mosquitoes, gnats, moths, and beetles.

Insects are the greatest rival man has. When man kills the enemies of insects he is upsetting the balance of nature.

In discussing local birds, insist that a child who condemns a certain bird back up his statements with evidence. Such information may be secured from state and federal departments of agriculture. Lead children to know that many false statements are abroad concerning animals. Help the children to get rid of such a notion as this — "A bat will entangle itself in your hair."

III. *Things to Think About* (p. 237). 1. See Craig's "Course of Study in Elementary Science, Grade IV," page 90. Read what is said about the following:

Tree sparrow	Shrike	Blue jay
Song sparrow	Starling	Bobwhite
Rose-breasted grosbeak	Meadow lark	Grackle
Catbird	House wren	Bat
Robin	Owls	

2. Animals keep the balance of nature and furnish food, clothing, and shelter for man.

3. Because they keep the insects from getting control of the world.

4. Mosquitoes, grasshoppers, beetles, caterpillars, cutworms, moths, ants, boll weevils, and so on.

IV. *Further Activities.* 1. Write to the Audubon Society for information regarding helpfulness of birds.

2. Read DuPuy's "Bird Friends and Foes." It is filled with valuable information about birds.

3. Write to the United States Department of Agriculture for pamphlets on birds.

4. Watch a bird for an hour. Record what you see him eat. See how many harmful insects he devours.

5. Let each child get authentic information concerning one bird or animal and present it in a report to the group. Encourage the children to report on birds which they have considered harmful.

Problem 2. **What Plants Do for Us.**

I. *Essential meanings for children.* Plants are essential to us. They give us food, clothing, and shelter.

Plants are used to add beauty.

Plants help hold soil to the earth.

Plants help to supply the air with oxygen.

II. *Information for the teacher.* Make it clear to children that all animal life is dependent finally upon plant life. That, even though some animals eat other animals, plants feed the animals which are eaten.

Much of our clothing is made from plants. Cotton, linen, and hemp are all products of plants. Just imagine what we should do without these three materials.

Consider the uses of plants in building shelter. From primitive times down to the present, man has always used plants for shelter.

Much of our food is vegetable matter. All our food is directly tied up with plants, even though part of our own diet is the flesh of animals, because all animals depend ultimately upon plants for food.

The importance of plants to the soil cannot be overlooked. They decay and so enrich the soil, making it fertile. Forests hold the soil to the earth. They prevent evaporation, erosion, and weathering of soil.

Many useful products are made from turpentine and rosin, such as varnishes, rubber substitutes, printing ink, leather dressing, papier-mache, and electrical insulation. Both turpentine and rosin come from plants.

Plants serve as homes for bird and animal life. The importance of sheltering bird life cannot be overestimated.

Encourage the children to plant flowers, shrubs, and trees to add beauty to the school grounds and their homes.

Emphasize the section on page 248 dealing with conservation of wild flowers. They have been greatly depleted. Enlist all your children in a campaign for the conservation of wild flowers.

Lead the children to discuss the economic value of plants, as:

1. Plants furnish material for clothes.
2. Plants furnish material for shelter.
3. Plants furnish food.
4. Plants are often used as medicine.
5. Plants help make the air pure.
6. Some plants are used for making dyes.
7. Plants add beauty to the earth.
8. Plants help keep soil and moisture in the earth.

III. *Things to Think About* (p. 253). 1. Plants are the ultimate food of all life.

2. Plants give us food, shelter, clothing, oxygen, commercial products, and fertile soil.

3. Egyptians used plants to make paper.

4. Indians used plants for making dyes.

IV. *Things to Do* (p. 253). 1. Shirt, dress, hose, rubbers.

2. Plants used in schoolroom:

Trees for wood of furniture.
Rubber tree sap for erasers.
Rags and wood pulp for paper.
Flowers to add beauty.

4. Add growing plants to the schoolroom.

V. *Further Activities.* Make a study of the parts of plants we eat. List them as below:

White potatoes: *stem*
Beans and peas: *seed*
Spinach: *leaves*
Lettuce: *leaves*
Apple: *fruit*
Cabbage: *leaves*
Asparagus: *stem*
Carrots: *root*
Turnip: *root*
Nuts: *seed*
Orange: *fruit*
Rhubarb: *leaves*

Unit VIII. Plants

The Larger Objectives. 1. Plants are largely dependent upon soil for growth.

2. Soil has to be fertilized to be good for plants.

3. Some plants reproduce from seeds, while others reproduce from spores.

4. Certain plants without seeds are called fungi.

Problem 1. How to Make a Garden.

I. *Essential meanings for children.* Sand, clay, and loam are kinds of soil.

Plant growth depends greatly upon the type of soil.

Simple tests can be made to determine the amount of sand, clay, or loam in soil.

It is important to select a well-drained and sunny spot for your garden.

It is important to have good seed.

It is important to keep the soil well cultivated.

The top crust should be broken from time to time.

II. *Information for the teacher.* It is not the idea in this unit to make professional gardeners of the children, but rather to acquaint them with the rudimentary facts regarding the subject and give them an experience from which they all benefit. Many schools maintain school garden plots and give children first-hand experience in gardening. If there is not space for a school garden, you may want to have a window-box garden.

Help the children to realize that the following factors are important to gardening as given in text:

1. It is important to select a place with sufficient drainage and sunlight for the garden. If you have a window-box garden, put it in a sunny place in the room.
2. It is important to have good seed.
3. It is important to prepare the soil well before planting. Work it with a hoe or shovel. If you have a large outdoor garden, it should be plowed. Plowing loosens the soil and allows roots to grow easily.
4. It is important to keep the soil well cultivated.
5. Weeds should not be permitted to grow in the garden. Weeds use the food in the soil which the plants need in order to grow. Tall weeds shade the smaller plants.
6. The top crust should be kept broken from time to time. This prevents evaporation and keeps the moisture in the soil.

Let the children have either an outdoor garden or an indoor one. Go through the above-mentioned processes, with the children doing the work. Discuss here the seed as a storehouse for the new plant.

Plant some beans in very sandy coarse soil. They will grow until the food stored in the seed is all used up. Then they will die. Every seed has a limited amount of food stored in it. When this supply is used up, the plant must make its own food.

Give the children actual experience in testing samples of soil. Directions for soil-testing are given in the text on page 260.

Soils differ greatly in their properties. The roots of plants must secure water from the soil. Water contains the materials necessary for their growth.

Soils are composed of gravel, sand, silt, clay, and humus. The first four were formed from rock. Humus is the result of partially decayed organic material. The percentage of these materials in the soil has a great deal to do with the growth of plants.

Have the children test soil as given on page 260. The soil must be thoroughly mixed into the water. It will settle in layers, the heavy particles at the bottom, the lighter ones on top. The layer which is thickest will tell you the kind of soil you have. Good soil must contain about 50 per cent sand. If more than that amount is used, add manure to fertilize it. If 50 per cent is clay, add slaked lime, coal ashes, or sawdust to separate the fine clay particles.

All children should have the opportunity to grow some plant. Bulbs and seeds may be planted. Encourage children to take pride in being good gardeners. Experiment with kinds of soil to determine the best soil for certain plants.

Be sure that the children realize that air, water, light, soil, and a moderate temperature are necessary for plant growth. The importance of some of these can be shown in the following experiment:

Plant the same number of seeds in each of four boxes, using the same kind of soil in each. When they are growing well, put No. 1 in the dark. Put Nos. 2 and 3 in the light at an ordinary room temperature. Place No. 4 in the light, but where it is cold. The class should record what happens and draw their own conclusions.

Children should become familiar with the parts of the plant and the uses of each. The roots get raw material. The stems transport food and water from roots to leaves. The leaves manufacture food. Fertilization takes place in the flower. Seeds have the power to produce new plants.

Seeds may be sown which will mature before school closes. Lettuce and radishes could be started in indoor boxes. Before school closes, the children could have a party using these vegetables for part of their refreshments.

When school closes, let some of the children be responsible for the garden. In the fall an exhibit of foods may be arranged. Such

vegetables as potatoes, beans, tomatoes, may be sold. The children might make chili sauce, or can the tomatoes.

If there are enough flowers for a flower show, an interesting assembly might be arranged exhibiting bouquets of flowers artistically arranged. The audience could cast a ballot to determine the prize bouquets.

III. *Things to Think About* (p. 265). 1. Choose a sunny spot; fertilize the soil; cultivate and water the garden.

2. Plant tulips for early spring blossoms.

Plant daisies for later spring flowers.

Plant phlox, bachelor's-buttons, and cosmos for later blossoms.

Plant asters, salvia, and chrysanthemums for fall.

3. Test soil to determine what fertilization is needed.

4. Water carries plant food from the soil into the plant.

IV. *Things to Do* (p. 265). All plants need water and good soil in order to grow.

Do not use much water when planting the potato.

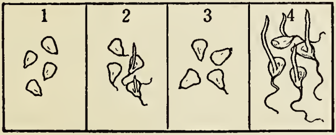
Keep it in the dark until it starts growing.

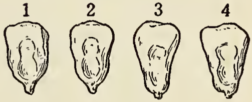
The vine will make an attractive decoration in your room.

V. *Further Activities.* 1. Read Kilpatrick's "The Child's Food Garden."

2. How to test seeds:

Suppose that you want to plant some corn, and wish to secure fine seed for planting. Square off a piece of blotting paper. Place





a kernel of corn from No. 1 ear on Square No. 1 and a kernel from No. 2 ear on Square No. 2, and so on. Cover the kernels with a damp cloth. Keep them in a dark room about five or six days. Keep them damp the whole time. Remove the damp cloth. The kernels that have sprouted best will tell you what ear to use as seed.

3. Cut off the top of a carrot and put it in water. See what happens.

4. Watch the bees visiting flowers. See if you can discover what the bees do for the flowers.

Problem 2. Plants Without Seeds.

I. *Essential meanings for children.* Plants which reproduce from spores are called fungi.

Fungi need no light in order to grow.

Fungi cannot make their own food.

Some fungi are harmful.

Some fungi are helpful.

Spores can be carried by the air.

II. *Information for the teacher.* Children will like to make mold gardens, directions for which will be found in the text on page 270. Let them grow the gardens on bread, on old shoes, and on damp clothes. The gardens grow best when kept in dark warm places.

Emphasize the importance of sunlight, cleanliness, and dryness in guarding against mold on food and clothing.

Take the children on a trip to a wood to discover fungus growths on trees and on the ground. You will surely find some "shelf fungus" which grows on sides of trees.

Cut open a mushroom and see if you can find the spores. They are in the brown dust on the underside of the umbrella part.

Fungi are plants, but differ from flowering plants in these ways. They do not make their own food. They do not need light in order to grow. They reproduce from spores rather than from seeds.

These spores are present in the air. When they lodge in favorable places they start growing. Spores reproduce and grow best in damp, dark places.

Toadstools, puffballs, shelf fungi, and molds are fungi. Some fungi live upon plants at the expense of those plants, causing rust on wheat, blight on potatoes and fruit, and smut on corn.

Long ago man was mystified about the fact that mold and mildew were often found on bread, shoe leather, and damp cloth. When spores were discovered in the air, this mystery was solved.

It is important that children recognize that all bacteria are not harmful. Some of them are helpful. Mold attaches itself to damp paper, cloth, leather, and food. It may do great harm to these articles. Bacteria make us a lot of work keeping things dry and clean. They kill many useful plants.

Many fungi are edible. Some, however, are poisonous, and because of the difficulty of distinguishing the good kinds people use

them but little. Mushrooms are fungi. Because some kinds are poisonous, it is not safe to pick your own mushrooms.

Yeast is a fungus growth. You can make it this way. Mix a handful of flour, a teaspoonful of sugar, a grated or mashed potato, and plenty of water in a dish. Let it stand in a warm place. It will ferment and make yeast. Perhaps you can make bread with the yeast you make. Invite some elderly lady to teach you how.

III. *Things to Think About* (p. 274). 1. Fungi are plants that reproduce from spores.

2. Fungi do not make their own food. They do not need light for growth. They reproduce from spores instead of seeds.

3. Shelf fungi, cheese mold, rot, rust, blight.

IV. *Things to Do* (p. 274). 1, 2, and 3. In growing these mold gardens be sure you put the bread, leather, or book in a warm, damp, dark place.

4. Follow the directions in the text.

V. *Further Activities.* 1. Find out why and how milk is pasteurized.

2. Why is it best to boil water when you are not sure it is safe to drink?

3. Fungi are used in making vinegar and sauerkraut. Find out how.

4. Take a field trip to discover how fungi attack trees.

Unit IX. Two Forces which Man Has Put to Work

The Larger Objectives. **1. Man has harnessed many forces of nature and made them work for him.**

2. Steam and electricity are two forces of nature.

Problem 1. **How Electricity Works.**

I. *Essential meanings for children.* Electricity is used to run engines and motors, to produce heat and light.

Electricity needs a circuit over which to flow.

When a circuit is not closed, a short circuit may result.

Dry cells can be used to furnish electricity.

II. *Information for the teacher.* Electricity is not fully understood; but, nevertheless, it is very interesting. All children have had some experience with frictional electricity. When combing your hair with a hard rubber comb, you often make frictional electricity.

Most children are very eager to experiment with dry cells and a bell. Let them try wiring a bell to the cells so that the bell will ring. Then let them add a push button to the circuit. Be sure they wire the outside post of one cell to the inside post of the other cell. Care should be taken to scrape off all wire ends before fastening them to the posts.

Dry cells are good for children to work with. They do not give shocks and are harmless. The inside of the cell is not dry. It is a moist paste. The cells have two posts on the top. The post in the center is the positive, or plus, post. The one at the edge is the negative, or minus, post. They are not alike.

In wiring a cell to a bell, you can attach the center post of the cell to one of the posts of the bell. Then attach the outer post of the cell to the other post of the bell. Make sure that all connections are tightly made. Now you have made a closed circuit over which the electricity passes from the cell to the bell and back to the cell again.

By attaching a push button, you can make and break the circuit at will. There is a piece of metal in the push button that is pressed against the wire of the bell when you push the button. This makes the circuit. When you release the button, the piece of metal no longer touches the wire and you break the circuit. When the circuit is broken, the bell will not ring.

Inside the bell itself is a magnet. When the current is turned on, the magnet pulls the clapper toward it. This breaks the circuit. The clapper springs back and makes the circuit. Back and forth it goes, making and breaking the circuit and ringing the bell.

In wiring lights be sure to keep the light wires from touching each other. If they touch and are not properly insulated, you will have a short circuit. If you are wiring a playhouse or a museum or a ship, you can control it with a push button just as you did the bell. Wherever you attach a socket for a light, you must scrape off all insulation. Make all connections tight.

Oftentimes you may want to splice wire. Twist one piece around the other several times. Cover all with insulation tape.

All wires should be insulated with either cloth or rubber. Both are poor conductors of electricity. They are called nonconductors, because they do not let electricity flow along them.

Copper is a conductor. It lets electricity flow along it. Most metals are good conductors.

III. *Things to Think About* (p. 290). 1. City wires often run underground for safety.

2. Dry cells, bell, push button, copper wire, tape, and pliers.

3. A conductor allows electricity to flow along it.

4. When electricity has a closed path along which to flow, the circuit is said to be closed.

5. When there is an open circuit and electricity flows out to other places than through the intended circuit, there is said to be a short circuit.

IV. *Things to Do* (p. 290).

1. Electric washer	Electric ironer
Electric flatiron	Electric toaster
Electric curling iron	Electric sweeper
Electric mixer	Electric lights
Electric refrigerator	Electric stove

2. Inside a dry cell is a carbon rod and moist black paste and a zinc plate.

3. Refer to text page 285.

4. Refer to text page 289.

5. Refer to text page 288.

V. *Further Activities.* 1. Let the children experiment with bar magnets to find out what materials are attracted and what are not.

2. Look at a compass. The needle points north. Now bring the bar magnet near the compass and see what happens.

3. Supply a hard-rubber comb, a glass rod, sealing wax, silk, wool, and cotton cloth. Let children experiment by rubbing each of the first three with each of the last three. Then let the children try to pick up bits of paper with them.

4. Find out where the electricity used in your city comes from. How does it reach your home?

Problem 2. Why Steam has Power.

I. *Essential meanings for children.* Steam has power to make things go.

Man has put this power of steam to work to run engines.

Steam engines have cylinders, pistons, and piston rods.

II. *Information for the teacher.* Every child has seen a bicycle tire pump. The parts involved in this simple pump help to explain

the steam engine. There is a cylinder, a piston, and a piston rod. The piston moving back and forth in the cylinder compresses the air in the cylinder. Likewise, the piston moving back and forth in the cylinder of a steam engine compresses the steam in the cylinder. Both compressed air and compressed steam have force.

Try to secure a simple cross-section model of a steam engine. The science laboratories of high schools often have such models. Then you can see exactly how the piston works.

You may be able to visit a roundhouse with the children. Let them find the cylinders, piston rods, and the connecting rods of locomotives.

Steam engines were first made by Watt to haul water out of the coal mines in England. These engines were stationary ones. Later George Stephenson made a traveling steam wagon to haul loads of coal away from the mines. It was many years before locomotives were used for passenger service.

The locomotive is of great value in transportation because it is used to push and pull thousands of trains all over the world. The stationary engine is of great importance in industry. It runs dynamos to generate power for factories; it propels steamships. It runs sawmills.

When water turns to steam, it needs seventeen hundred times more room than it did in its liquid state. This steam, compressed into a cylinder, can be made to push and pull heavy loads by working the piston rod which is fastened to the connecting rods of the driving wheels of the engine.

III. *Things to Think About* (p. 297). 1. See text page 292.
2. Steam runs engines and dynamos. It produces heat.
3. Locomotives, stationary engines, and heating systems.

IV. *Things to Do* (p. 298). 2. The air you feel is compressed air.
3. See the picture on page 296.

V. *Further Activities.* 1. How many different uses of the steam engine can you find in your neighborhood?

Some steam engines are stationary, others are traveling ones. Are both used near your home? Is the steam engine of a boat a stationary engine?

2. Visit a dynamo and see if you can see the work of steam there.
3. Read about Robert Fulton's first steamboat.

LIST OF EXHIBITS TO BE MADE BY THE CHILDREN AND TEACHER

1. Collection of soils.
2. Collection of rocks.
3. Collection of seeds.
4. Collection of waxed leaves.
5. Collection of pressed flowers.
6. Collection of nature pictures.
7. Collection of birds' nests.
8. Collection of insects' nests.
9. Collection of wasps' nests.
10. Collection of bees' nests. (Collect nests only in the fall.)
11. Collection of cocoons.
12. Stock an insect wire cage with caterpillars, spiders, crickets, and grasshoppers.
13. Stock an aquarium with fish, snails, newts, turtles, and plants.
14. Build bird houses, baths, and feeding trays to use in the school yard.
15. Make an observation ant colony in a glass jar.

LIST OF EQUIPMENT CHILDREN CAN MAKE

1. Wire net insect cage.
2. Window boxes for plants.
3. Cases for leaf, seed, flower, rock, and other collections.
4. Aquarium for turtles, salamanders, alligators, and toads.
5. Case for filing nature pictures.
6. Bird houses.
7. Bird bath.
8. Feeding trays for birds.
9. Class museum case (open shelves).
10. Cloth insect net.
11. Cloth fish net.

SUGGESTED LIST OF EQUIPMENT

With a few pans, bottles, corks, and canned heat, most of the experiments suggested in the textbook can be carried out. Much of this equipment can be used by many rooms in the same building.

Below is a list of simple equipment which any group of children and a teacher could easily collect for carrying out the work suggested in the textbook. This list is made on a basis of thirty pupils to a class.

Alcohol (canned-heat)	1
Aquarium	1
Barometer (aneroid)	1
Beakers	3
Bell wire	25 ft.
Bottles	½ doz.
Corks	1 doz.
Dry cells	3
Electric bell	1
Filter paper	1 pkg.
Glass funnel	1
Glass stoppers	3
Glass tubing (narrow 3/16″)	15 ft.
Globe	1
Hammer	1
Insulating tape	1 roll
Jackknife	1
Magnifier (reading glass)	1
Medicine dropper	1
Push button	1
Quart and pint milk bottles	2 each
Rubber stoppers	1 doz. (assorted sizes)
Rubber tubing (narrow 3/16″)	
Rulers	10
Saucers	½ doz.
Scissors	1 doz.
Shallow pans (white enamel)	½ doz.
Shovel	1
Small steam engine	1
Test tubes	½ doz.
Thermometer	1
Tin cups	2
Tumblers	½ doz.
World map	1
Yardstick	1

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Date Due
